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THE CRISIS BETWEEN SCIENCE AND SOCIETY—A MODERN PARADOX[1]

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At the New York meeting of the American Association for the Advancement of Science, held last December, a report was given by the Committee on Social Aspects of Science (Pigman *et al.*, 1957). To the public at large this report was received as one of the most significant contributions of the convention. The public press gave it wide publicity; science writers commented in detail; a few publications reprinted the entire report of the committee. Much discussion and comment were stimulated throughout the country.

This report makes clear that ". . . there is an impending crisis in the relationships between science and American society. This crisis is being generated by a basic disparity. At a time when decisive economic, political, and social precepts have become predominantly dependent on science, the discipline has failed to attain its appropriate place in the management of public affairs." The report also makes clear that " . . . there are indications that the public interest in science is not commensurate with the important role of science in society."

Since the Renaissance, and especially since the Industrial Revolution, there has been no force greater in the development of Western civilization than the development and application of modern science. We have gone progressively through the ages popularly called the Iron, Steel, Machine, Air, Electronic, and finally the Atomic Age. Each has appeared following a shorter interval of time as science has advanced at a tremendous rate of acceleration. Almost every aspect of modern life depends upon scientific development—our communication, transportation, utilities, agriculture, manufacturing, medical treatment and health preservation, etc.—at every turn we are served by innumerable developments of science and technology. Yet, in spite of this dependency upon modern science, there is an ever widening gap between science and society. Scientists as a working group are becoming more and more isolated, and as scientific knowledge increases, the public has less and less understanding and appreciation of the works of science. It is indeed paradoxical that contemporary society neglects the very source of its modern development.

Attitudes of the general public towards scientists are alarming. While everyone enjoys the fruits of science, little does the average person realize the source of these advantages which modern science has bestowed upon him. Our youth look upon scientists as "eggheads," "long-hairs," and "squares." In a recent survey (Purdue Opinion Panel, 1956) it was reported that 25 percent of the college students interviewed think that scientists as a group are more than a little bit "odd," and 14 percent think there is something evil about scientists. As a social group they are rated comparatively low in prestige by the youth of our country. Even lower on the scale is the prestige of science teachers. It is becoming increasingly

[1]This paper was read as an Honors Day Address at Kent State University on May 29, 1957.

difficult to attract good students to a career in science education. In this case a comparatively low financial reward is coupled with the unappreciative attitude toward science in general.

This attitude is often imparted to youth by their teachers and other adults who carelessly create an unfavorable impression. People often do not realize the harm done by derogatory remarks, even when not made to be taken seriously, or when given out merely as incidental statements. These slighting remarks may become seeds which will later grow into antagonistic attitudes. Recently this problem has been summarized with a suggested solution by Michael (1957). Scientists should take the initiative in correcting this situation.

The public press and other media of mass communication exert a great influence in shaping public opinion. The A.A.A.S. report (1957) states that ". . . science receives an unduly small share of the budget of newspaper space or broadcasting time. The situation reflects a rather low level of interest in science on the part of the public." On the other hand a recent survey (Anon, 1956) has shown that newspaper articles on scientific subjects are consistently among the most interesting to newspaper readers. Possibly it is the erroneous belief of journalists that the public is not interested in matters of science which results in such poor coverage, thus creating a vicious cycle. Better press relations could do much to strengthen the ties between science and the public.

A recent example of damaging reporting appeared in a nationwide syndicated column (Fulton Lewis, 1957). It was entitled "Zany Projects" and was an attack upon the spending of tax money by the National Science Foundation for scientific projects which to the columnist appeared to be "zany." A number of selected titles were given to illustrate the argument. Undoubtedly to the uninitiated, the projects may seem of little value if not entirely worthless. Apparently the writer of the column was not familiar with the stand taken by Warren Weaver (Piel, 1955) who said, "The most imaginative and powerful movements in the history of science have arisen not from plans, not from compulsion, but from the spontaneous enthusiasm and curiosity of competent individuals who had the freedom to think about things they considered interesting." Before the days of penicillin a research project on bread mold would certainly appear to the writer of this newspaper column as a "zany project." In the mid-nineteenth century a financial grant would not likely have been given to Faraday or Clark-Maxwell for pioneer research on electricity, but our columnist would not likely hesitate to recommend a grant for the scientific study of the gas light, as Harrison Brown (1956) has so well pointed out in his article on "The Case for Pure Research." He then summarized with the statement, "Too few laymen recognize the extent to which the eventual practical applications of a scientific discovery are unpredictable." Warren Weaver (1955) puts the matter this way; "An important characteristic of science . . . is its incapacity to be impractical." A past president of The Ohio Academy of Science (Rea, 1926) earlier put forth this same idea with his statement, "Useful inventions are invariably developed from apparently useless knowledge." The public does not seem to realize that pure research leads to new knowledge which is the capital upon which applied science draws for development.

Scientists are partly to blame for the situation because they have too often remained aloof from the rest of society. Scientists often ignore social issues and are even notorious for their negligence in supporting their own cause. A recent study by the American Association for the Advancement of Science (A.A.A.S., 1955) points out how poorly the majority of American scientists support their own professional organizations. They are also guilty of being ignorant of what is going on in branches of science outside their own specialty as well as in public affairs. Quincy Howe (1956) has shown that the use of modern weapons is gradually breaking down the barriers between scientists and the public, and he regards this as a significant move in the right direction.

One of the most important aspects of the crisis between science and society today is that of training teachers and educating the public-at-large in the field of science education. There has been a marked dwindling of enrollment in the science courses of our schools generally. Fewer college students are preparing for science teaching, and many who have recently entered the field are not well prepared. The National Science Foundation, the A.A.A.S., state academies of science, and other organizations are attempting to improve science teaching through summer institutes and fellowships for further training to raise the level of quality and to attract competent young students to this field. Today it is necessary to have active recruiting to entice young people to prepare for the teaching of science and mathematics. There is danger, however, that such programs may take on the attributes of high-pressure salesmanship. Youth should be motivated towards careers in science and science teaching for the professional satisfaction these careers can offer rather than fancied rewards which seldom are realized. Financial rewards cannot be offered to attract teachers, but strangely enough even the attractive salaries offered by technology and engineering have not resulted in bringing sufficient people into these fields to meet the ever-growing demand. J. W. Still (1956) recently stated in a communication to the editor of *Science*, "Young people are taking a dim view of both basic and applied sciences as a career." It was encouraging to read in a recent issue of our local paper, the *Record-Courier* (1957), that a report compiled by a committee of citizens on planning a new high school stated "The people expressed the view that there should be an increasingly strong program in the fields of science and mathematics—those surveyed (90%) believed that science and mathematics facilities of the new building should take precedence." It is encouraging to see a public group realize the importance of the teaching of science and mathematics to modern youth. Also, it is only fair to point out that while considerable emphasis has been given recently to the poor preparation of many science teachers and to the inadequate science program in many schools, it should not be forgotten that we do have many fine teachers of science who are doing admirable work in teaching science and in stimulating their students to pursue a career in science. There are many science teachers with advanced training who have resisted temptations to take more remunerative employment elsewhere because of their interest in high school youth and the satisfaction they derive from stimulating and encouraging young people in their classes and laboratories. Each year as I attend the district and state Science Day exhibitions, sponsored by The Ohio Academy of Science, I marvel at the creativeness and productivity of our better high school students. Many of the projects are of such quality they would do credit to far more advanced students. Indeed there is a good deal of fine science teaching accomplished today, and there are many promising students who are looking forward to a career in science or science teaching; but unfortunately, the number is not great enough to meet the increasing demands for research workers, technologists, engineers, and science teachers. It is the duty of society to provide our gifted young people with suitable training and adequate facilities to develop their natural abilities and head them toward a satisfying career in science and science education. It is obvious that without meeting the demands for qualified science teachers, the production of scientists will dry up at the source.

In contrast to the situation in the United States, we receive reports that the Russians are making tremendous strides in the training of scientists, technologists, and engineers. Indications are that the rate of increase of these specialists in Russia will continue to be greater than ours (Dargush, 1957). Also, London (1957) has warned us not to regard Soviet science in the light of the unsavory situation created by the farce of Soviet genetics. In other disciplines the Russian scientists have been able to advance one way or another without being hindred by political doctrine. Merle Fainsod (1957) wrote a few months ago of "The

technical dynamism running through Soviet society." He noted, "The important people were engineers and scientists. . . . The university is an interesting mirror of the values of Soviet life, with science and technology very much in the forefront." In European countries, in general, scientists are very highly respected; in many cases they rate higher in the social scale than the physicians and surgeons. It has recently been called to our attention by John Lear (1956) that "Soviet Russia is assigning scientific attaches to its embassies for the first time in its history—the United States has no scientific attache anywhere." It is unfortunate that our top officials concerned with problems of a scientific age are rarely trained in a scientific tradition. Several years ago the Executive Committee of the A.A.A.S. made clear that "In our modern society it is absolutely essential that science—the results of science, the nature and importance of basic research, the methods of science, the spirit of science—be understood by government officials, by business men, and indeed by all the people." Science needs better representation in our government at the higher levels.

While comparisons are interesting, we must not draw the conclusion that Russian scientists play the important role in society which the above statements would seem to indicate. A news item recently published in *Science* (Anon, 1957) informs us that "A majority of the Soviet Union's most eminent mathematicians and physicists have challenged the present political control of Soviet science. They appear to have made progress in their demand that leading Soviet scientists be allowed democratic control over the development of Soviet science." While we can not boast of the tremendous increase in the training of technicians currently being attained in Russia, our scientists do not come under such political control, the ends of which might be questioned by democratic people.

While modern science on one hand has improved health, longevity, comfort, wealth, and security, it has on the other hand raised a serious threat to all of these. With industrial development there have long been problems of air and water pollution. Now a new source of environmental contamination has been created. Radioactive fallout from atomic and hydrogen bomb testing poses a serious problem. We are assured by some authorities that the level of fallout at the present time is far below the toleration level. Just last week a front page story in the *Cleveland Plain Dealer* (Robertson, 1957) carried the claim of a radiologist that radioactive fallout in the atmosphere is no more serious than the luminous dial of one's wristwatch. However, Albert Schweitzer (1957), who has joined the leadership for abandoning hydrogen bomb explosions, calls our attention to the possible consequences of even low level contamination. In his report the following case was cited. When the radioactivity contamination of the Columbia River was analyzed, it was found to be at a very low level. However, the radioactivity of the microscopic plants and animals living in the river was 2000 times higher, that of the fish feeding on these organisms was 15,000 times higher, and that of ducks eating the aquatic life was 40,000 times higher. Nestling swallows, fed on the insects coming from this river, had a radioactivity level 500,000 times greater, and in the egg yolks of water birds feeding in this area the radioactivity level was 1,000,000 times greater than in the water itself. Apparently in this case the plants and animals living in a medium of relatively low contamination concentrated the radioactive materials in their bodies. Should man enter this food chain by eating the fish and game which have acquired a high level of radioactivity, man would become endangered even though the atmosphere and the waters about him may show a low level of contamination. The study of Henderson, Robeck, and Palange (1956) on the Columbia River showed that "The river organisms concentrate radioactive materials to a considerable degree, up to nearly 10,000 times the total beta activity in the river water." They concluded, "Because fish and other aquatic organisms concentrate radioactive materials many times above the levels found in water, the use of these organisms for human or animal consumption

presents a potential public health problem." It was calculated, however, that as of that time the levels of radioactivity in the flesh of the fish studied were not dangerously high.

Strontium 90, which makes up the bulk of radioactive fallout, behaves chemically much like calcium, and hence this radioactive strontium accumulates and becomes concentrated in the bone tissues. Here it is close to the blood forming tissues in the bone marrow and is capable of producing fatal blood diseases. Last week a very important article by E. B. Lewis (1957) concluded after a very searching study, "It is estimated that a five to ten percent increase in the current spontaneous incidence of leukemia would occur if the population were to reach and maintain a body level of strontium 90 amounting to 1/10th of the 'maximum permissible concentration.'" An editorial comment on this article (DuShane, 1957) concluded, "It is apparent that the atomic dice are loaded. The percentages are against us and we ought not play unless we must to assure other victories."

To date, many scientists are at sharp disagreement as to the actual and potential hazards of radioactive fallout as illustrated in some of the recent literature (Libby 1956a, 1956b; Libby, Brown, and Lear, 1957). Two trends are not without significance. The level of maximum permissible concentration has consistently been lowered, and even the strongest arguments given against fear of fallout dangers have recently been tempered with the admission that potential danger does exist whether or not damage is present now from past explosions. Lapp (1957) has pointed out, "Values for MPC have been revised downward steadily during the past two decades as more knowledge of the ultimate biological effect of skeletally retained radioelement has accumulated." Libby (1956a) is confident that up to the present time the amount of fallout has not reached a dangerous level. He wrote, "It is possible to say unequivocally that nuclear weapons tests as carried out at the present time do not constitute a health hazard to the human population insofar as radiostrontium is concerned." However, it is well to keep in mind the statement by Snyder (1957) that "The able and authoritative summary reports on the biological effects of atomic radiation by the committees of the National Academy of Science which studied this question expose our serious deficiency of many fundamental data. This deficiency is perhaps nowhere so conspicuous as in the area of genetics, and particularly the genetics of the human species." It is clear that atomic energy is not an unmixed blessing. Much is promised to man with the development of atomic energy, but it is not without its own inherent dangers. It can raise the standard of living, improve health, fight disease, furnish unprecedented energy, revolutionize industry, or it could lead to the ultimate annihilation of man, either directly by devastating war or the contamination of natural resources and internal degeneration of man through disease. Snyder (1957) sums up the situation this way, "It would be indeed tragically ironic if the same thermonuclear reactions that, by taking place in the sun, make possible our very existence on this earth, should, through our own social bungling, lead to our destruction."

It is very clear how modern science affects society. However, it is neither obvious nor commonly realized that the reciprocal relationship is also true. Society bears great influence on the development of science, particularly of the applied sciences. Hafstead (1957) recently stated the matter succinctly: "It is society itself, and particularly the nontechnical part of society, which creates the demands which are the motive force behind our technology." Albert Schweitzer (1957) emphatically states, "Public opinion of this kind—works through just being there." In the final analysis it is society itself which dictates the course of applied science and technology.

The periodic proposals of a moratorium on scientific advancement are certainly not a solution to the crisis between science and society. Considering the benefits derived from the past accomplishments of science and technology, it is somewhat

surprising and paradoxical that a crisis should exist at all. We are in the midst of a scientific revolution. It may lead to a better world; it could lead to pandemonium. Society is becoming more and more dependent upon science, but society in the end will tip the scales in the direction toward which science shall proceed. Increased knowledge leads to increased control of the environment and the harnessing of the forces of nature for the benefit of man. Learning to adjust to a new technology rather than stopping the program for society to catch up, seems to me to be the only rational solution. And hand in hand with working toward harmony between science and society, is an undercurrent of moral issues involved in striving for a better and fuller life. Solutions to these problems will not be easy. Time has permitted only a brief mention of but a few of the many problems facing modern man and his relations to science. Will the crisis lead to cooperation or to chaos, a better life or annihilation? The responsibility rests equally upon science and society.

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THE PUPARIUM OF *RHAGOLETIS BASIOLA* (O.S.): VARIATION IN LENGTH AND FORM

(TRYPETIDAE, DIPTERA)

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INTRODUCTION

While observing insects associated with hips of roses in 1945–1951, I reared numerous puparia of the rose hip fly, *Rhagoletis basiola*. Seeing that the puparia varied decidedly in length and form, I measured several thousands in order to determine the nature, and possibly the causes, of the observed variation. The materials measured were acquired in a period of six years from the states of Ohio, Illinois, Wisconsin, and Minnesota where they originated in five species of *Rosa* listed in table 2.

Two kinds of mensurational data are presented for interpretation in the pages below. One pertains to length only of the puparia, the other to the length and maximum diameter of the insect. Since the oval straw-colored bodies are normally perceptibly depressed, the diametric measurement refers to the width or transverse dimension. The data concerned with length only impart some idea of size, whereas those pertaining to length and diameter combined have to do with form or volume.

METHOD

Table 1 illustrates the method employed for analyzing the mensurational data. In the upper half a sample of puparia is classified according to variation in length, and in the lower part another sample is divided on the basis of volume, shape or form. Both "length" and "form" data are distributed into eight parallel groups of equal extent or inclusiveness. The length groups are delimited in terms of millimeters: *e.g.*, group 1 consists of puparia whose length ranges from 3.0 to 3.49 mm., and group 8, of puparia 6.5 to 6.99 mm. long, while the limits of groups 2 to 6 intergrade between these extreme groups 1 and 8. By contrast, the bounds of the eight form groups are stated in terms of relative lengths and diameters, *i.e.*, ratios. For example, the puparia of form group 1 have extreme ratios of 1.77:1 and 1.99:1. These are the most robust, but not necessarily the smallest puparia. Here 1.99 signifies the puparia are 1.99 times longer than their maximum breadth, and not 1.99 mm. long by 1.0 mm. wide. The distribution of the puparia composing any sample among the two series of groups is given in terms of percents. As illustrations, note that 64.32 percent of the puparia parasitized by *Halticoptera* (table 1) fall into length group 3, whose limits are 4.0 and 4.9 mm., and 37.21 percent of a comparable sample occur in form group 3, whose extreme ratios are 2.25:1 and 2.49:1.

RESULTS

Samples analyzed.—Altogether 15 samples of puparia, totalling approximately 6,800, were analyzed to determine their percentile distribution with reference to length and form, according to the above method. Three of these are presented in full in table 1. The "majorities" of all the 15 samples will be found in table 2.

General nature of variation in length.—When analyzed with reference to their percentile distribution among the eight length groups, the 15 samples are found to constitute three distinct, although unequal, classes. In characterizing these classes, I consider only the numerical "majorities" of the several samples instead of the total puparia: this for the reason (1) that the majorities are the most signi-

TABLE 1

Puparia in relation to parasitism

Effect of parasites on length of 1149 puparia

Parasites in the puparia	Puparia measured	Numerical limits of eight groups based on length of puparia, in mm.							
		puparia 3.0–3.49 mm. long	puparia 3.5–3.99 mm. long	puparia 4.0–4.49 mm. long	puparia 4.5–4.99 mm. long	puparia 5.0–5.49 mm. long	puparia 5.50–5.99 mm. long	puparia 6.0–6.49 mm. long	puparia 6.5–6.99 mm. long
Halticoptera	243	5.95%	21.08%	64.32%	8.65%	0.00%	0.00%	0.00%	0.00%
Opius	373	1.17	8.19	44.73	38.30	7.31	0.30	0.00	0.00
None	533	2.06	7.32	18.76	30.20	30.02	11.26	0.38	0.00

Effect of parasites on form of 1059 puparia

Parasites in the puparia	Puparia measured	Numerical limits of eight groups based on form, i.e. ratio of length to diameter, of puparia							
		1.77:1 to 1.99:1	2.0:1 to 2.24:1	2.25:1 to 2.49:1	2.50:1 to 2.74:1	2.75:1 to 2.99:1	3.0:1 to 3.24:1	3.25:1 to 3.49:1	3.50:1 to 3.75:1
Halticoptera	230	0.00%	26.74%	37.21%	23.83%	4.65%	6.41%	1.16%	0.00%
Opius	319	1.36	36.27	49.14	11.87	1.36	0.00	0.00	0.00
None	510	2.94	25.89	45.49	19.60	4.51	1.18	0.00	0.39

ficant fractions as indicators of the nature and amount of variation among the puparia, and (2) their variational values are more conveniently described than those of the entire samples. With few exceptions, the minorities of the samples prove to fall into all the length groups that do not contain the majorities, but they vary with reference to the number of percents per group.

Class I. The majorities of the 12 samples (table 2) which constitute this class, range from 72.65 to 85.99 percent, with a spread of only 13.34. Moreover, all these samples fall into the same length groups 3, 4 and 5, whose inclusive extremes are 4.0 and 5.49 mm. Therefore, while not strictly uniform as to size of their component puparia, the samples are fairly compact or homogeneous as components of their class. The antecedent larvae, from which the puparia developed, origi-

TABLE 2

Percental Values of "Majorities," in Groups 2–6, based on Length of Puparia

Distribution of the majorities of the 15 samples as based on the length of the puparia

	Limits of "majority" groups 2–6, in mm.				
	No. 2	No. 3	No. 4	No. 5	No. 6
Sources of samples	3.5–3.99	4.0–4.49	4.5–4.99	5.0–5.49	5.5–5.99
			Class I		
Northeastern Minnesota		80.67 per cent, groups 3–5			
Northwestern Wisconsin		78.45 per cent, groups 3–5			
East Central Illinois		75.64 per cent, groups 3–5			
Random areas		78.92 per cent, groups 3–5			
Year 1945		85.99 per cent, groups 3–5			
Year 1946		81.49 per cent, groups 3–5			
Year 1949		72.65 per cent, groups 3–5			
Year 1950		83.06 per cent, groups 3–5			
Rosa acicularis		83.34 per cent, groups 3–5			
Rosa blanda		76.09 per cent, groups 3–5			
R. blanda and *carolina*		77.08 per cent, groups 3–5			
Parasite-free puparia		78.98 per cent, groups 3–5			
			Class II		
Rosa palustris, Urbana			83.10 per cent, groups 4–6		
			Class III		
Parasitized by *Halticoptera* sp.	85.40 per cent, groups 2–3				
Parasitized by *Opius* spp.		83.03 per cent, groups 3–4			

nated as follows (table 2): (a) in three distinct geographical locations; (b) in four separate years; (c) in three species of roses; and (d) in miscellaneous localities, years and roses. The latter (d) has reference to sample 12: all the puparia were dissected after measurements and thereby shown to be free of parasites. Puparia from a, b, and c contained parasites in varying numbers.

About 93 percent of the total lot of more than 6800 puparia concerned in this investigation are included in the 12 samples of Class I. That so great a preponderance of the over-all lot of individuals is so nearly similar in length, despite the diversity of places, times, rose hosts and rates of parasitism, signifies that the sum of the environmental influences was comparatively constant in most times and natural conditions.

Class II (table 2). This fraction of the over-all lot of puparia consists of a single sample. It was derived from the hips of *Rosa palustris* cultivated under somewhat ideal conditions at Urbana, Illinois. This class differs from Class I

in that its majority of 83.10 percent belongs to length groups 4, 5 and 6; *i.e.*, its puparia measure from 4.5 to 5.99 mm. in length. An additional 12.09 percent of this sample fall into group 7, measuring up to 6.5 mm. Accordingly, these puparia average decidedly larger than those of Class I, and are the largest I have obtained from any and all sources in the years 1945–1951.

Class III (table 2). This class consists of two samples of puparia. Both were shown, by means of dissection, to be wholly parasitized, one by the pteromalid chalcidoid, *Halticoptera rosae* Burks, the other by the braconids, *Opius balduf* Mues. and *O. rosicola* Mues. The "majority" of the puparia inhabited by *Halticoptera* amounts to 85.40 percent, and falls into length groups 2 and 3. Being only 3.5 to 4.45 mm. long, this majority contains the smallest puparia known to me. The majority of the puparia attacked by *Opius* spp. adds up to 83.03 percent and belongs to length groups 3 and 4, which measure 4.0 to 4.99 mm., hence are slightly larger than those parasitized by *Halticoptera*.

Variation among the majorities of the samples.—In addition to the variations described for the three classes above, diversity in length of the puparia is shown also in the percentile distribution within the majorities of the 15 samples. In some instances, these groupwise differentials vary to a significant extent. Such variation is exemplified by the following cases.

In the sample (table 2) obtained at Eaglesnest, near Ely, in north-eastern Minnesota, the percentile distribution among length groups 3, 4 and 5 was 30.78, 28.82 and 21.07, respectively (total 80.67 percent). This tendency of the puparia to the small groups 3 and 4 may signify a fairly high rate of endoparasitism, or other factor strongly reducing size of this fly stage. In the sample from northwestern Wisconsin, but mostly Chetek, the groupwise percentile distribution was 22.62, 25.44 and 30.39 (total 78.45), meaning that this particular sample averaged larger than those from Eaglesnest, and possibly indicates a lower rate of parasitism, or other restricting factor. In the sample from eastern Illinois, but largely Champaign County, the pattern was 12.18, 29.17 and 34.29 percents (total 75.64). Accordingly, the puparia from Eaglesnest averaged smaller than those from Wisconsin, and both these proved smaller than the sample that originated in Illinois.

Similar differences of a more or less distinct degree appear in all the 15 samples. I do not interpret these diversities in percentile patterns in the majorities to be fortuitous, but believe they represent the varied effects of several factors whose individual influences on the growth of *Rhag. basiola* differ in magnitude with time and circumstance.

Comparison of variation in (a) length and (b) form.—Considering the 15 samples as a whole, the puparia show an extreme variation in length of approximately 3.00 to 6.90 mm., with the "majorities" distributed over the five length groups numbered 2 to 6 (table 2). But when treated for variation in form, expressed in terms of ratio of length to diameter, these majorities of the samples fall into three adjacent form groups, numbered 2, 3 and 4 (table 1), whose extreme ratios are 2.00:1.00 and 2.74:1.00. This relative uniformity in the form samples is reflected also by the ratios presented in table 3, where the data given under "average form" are found to be closely similar despite (a) the absolute differences in the samples as regards parasitism, and (b) the origin of the three lots, A, B and C, in various habitats.

What is the meaning of the observed differences between length and form of the puparia? On first thought, it may seem that length and form are distinct aspects of size, which might be interpreted to signify either the operation of distinct causative factors for length and form, or that one and the same factor or factors may effect a proportionately greater change in the diameter than in the length of a puparium. However, the hypothetical two "types" of variation are basically identical, and only appear to be distinct due to the two distinct mathematical devices employed to break the samples down into the length groups and

form groups, respectively. Ratios are calculated by dividing length by diameter, and they therefore represent values intermediate between the two basic dimensions. The extremes of length and width are minimized in this method of expressing variation, and, as a consequence, the "majorities" of the several samples, when classified on the basis of form, appear decidedly more homogeneous with one another than when divided according to variation in the longitudinal dimension only.

As a means of expressing variation, length is preferred over form, or ratio, for the reason that it serves to emphasize rather than minimize the lines of demarcation existing in the puparia. The diverse differences revealed by measurements of length serve further to indicate, or even to identify, the ecological factors that operate as causes of variation, whereas the data on form or ratio give comparatively little intimation of such causes.

Causes of variation in length.—Table 2 suggests clues as to the identity of factors that may be associated, in causative relations, with variation in length of the puparia. However, the observation that 12 of the samples (Class I) belong to groups 3, 4 and 5, with extreme lengths of 4.0 to 5.49 mm. and are therefore comparatively uniform in length, indicates that the geographical sources, years of acquisition, the plant hosts, *Rosa acicularis*, *blanda* and *carolina*, and the parasite-free condition of the twelfth sample, did not, as entities, exert major influences on the length of the puparia, or it indicates that some of the factors involved in each situation operated counterwise to others to produce the observed uniformity. By contrast, Classes II and III stand distinctly to the right and left, respectively, of Class I (table 2). Hence, it appears that the greater length of the puparia of Class II may be attributed to the favorable qualities of their host, *Rosa palustris*, and that the smaller lengths of those in Class III correlate with parasitism by *Halticoptera* and *Opius*.

Rosa palustris as a cause of large size.—That puparia of Class II exceed in size those of Class I is due largely to the influence of *R. palustris* appears certain when we examine the circumstances under which this particular rose grew. It was distinctive in that it was cultivated in rich soil, fully exposed to the summer sun, mature in size, vigorous of stem and lush in foliage. The hips grew large, and when ripe in September-October, had become a rich brownish-red color, and probably contained a high percent of vitamin C. Melville and Pyke (Proc. Linn. Soc. Lond., p. 159, 1946) have shown that this vitamin attains its maximum volume when the hips of the several British species are ripe late in the growing season. I have found that the larvae of *Rhag. basiola* are, generally, approaching their maturity at that time of year. It may therefore be supposed that the vitamin indirectly contributes significantly to the exceptionally large size of the puparia derived from this clump of roses.

However, it is improbable that the flourishing state of these plants is the sole cause of the large puparia. Dissections of sample puparia from this source revealed that *Halticoptera* did not occur and *Opius* spp., present in small numbers elsewhere in eastern Illinois, had not invaded the garden where *palustris* thrived. That parasitism effects a reduction in the length of puparia is apparent from the position of the parasitized sample in Class II (table 2).

Parasites as factors in variation (table 1).—Three samples, totalling 1149 puparia, obtained largely from northwestern Wisconsin and northeastern Minnesota, were dissected to determine the species of parasite affecting them, and analyzed with reference to the bearing of these internal enemies on variation in length of the puparial host. One sample consists of puparia which proved to contain the first instars of *Halticoptera*; a second contained various instars of *Opius* spp.; and the third was free of all parasites. Data in table 2 show that the majorities of the puparia parasitized by *Halticoptera* fall into groups 2 and 3. Being only 3.5 to 4.49 mm. long, these were the smallest puparia discovered, which

indicates that this parasite effects an extreme reduction in the size of the host. That *Opius* spp. did not reduce the host to the same extent as *Halticoptera* is shown by the position of the majority puparia in length groups 3 and 4, which measured 4.0 to 4.99 mm. How this differential between *Opius* and *Halticoptera* is achieved may be seen below from their distinctive impacts on the host.

The two genera are similar in their host relations in that both persist as first instars while the host larvae feed and grow to maturity. Both feed sparingly in the larvae of *Rhagoletis* and thereby enable the host to mature and to pupate. However, the similarity ends here. The female *Opius* places the zygotes in the larva of the fly, usually the second and third instars, whereas *Halticoptera* oviposits into the embryo of the host fly, where the first instar parasite hatches. Accordingly, the first larva of *Halticoptera* exerts its retarding effect on the development of both the embryo and all the three instars of the host, whereas the first larva of *Opius* works counter to only the second and third instars, and sometimes

TABLE 3

Parasitism in relation to form based on a sample of 1264 puparia

Lots and sources of puparia	Parasitized by *Halticoptera*		Parasitized by *Opius*		Not parasitized	
	Extremes of form	Average form	Extremes of form	Average form	Extremes of form	Average form
Lot A, *Rosa acicularis*, Eaglesnest, Minnesota	3.0 x 1.5 and 4.8 x 2.0 mm.	249 puparia 4.02 x 1.76 mm., or 2.28: 1	3.05 x 1.15 and 5.7 x 1.95 mm.	340 puparia 4.34 x 1.9 mm., or 2.28: 1	3.0 x 1.3 and 6.0 x 2.5 mm.	131 puparia 4.93 x 2.12 mm., or 2.33: 1
Lot B, *Rosa blanda*, Eaglesnest, Minnesota	3.1 x 1.1 and 5.0 x 2.0 mm.	98 puparia 4.12 x 1.74 mm., or 2.31: 1	3.3 x 1.3 and 5.1 x 2.2 mm.	25 puparia 4.25 x 1.76 mm. or 2.42: 1	3.8 x 1.2 and 5.9 x 2.8 mm.	107 puparia 4.64 x 2.0 mm. or 2.32: 1
Lot C, *R. blanda* and *carolina*, Chetek, Wis.	3.05 x 1.05 and 4.9 x 2.0 mm.	187 puparia 3.94 x 1.65 mm., or 2.39: 1	3.4 x 1.2 and 5.1 x 1.92 mm.	18 puparia 4.2 x 1.74 mm., or 2.41: 1	3.01 x 1.1 and 5.65 x 2.5 mm.	109 puparia 4.53 x 1.92 mm., or 2.36: 1

probably only the third. This differential effect on the growth of the host, as reflected in the length of the puparia, comes about despite the somewhat larger size of the first instar *Opius*. It therefore appears that the relatively subdued but long-time attack of the smaller *Halticoptera* on embryo and larva of *Rhagoletis* more than offsets the advantage held by the larger and more aggressively adapted first instar of *Opius*.

That parasites cause reduction in length of the puparia may be inferred also from the above observation that the exceptionally large puparia from *Rosa palustris* contained no *Opius* or *Halticoptera*. The data presented in table 3 pertain to the forms of puparia parasitized by these same enemies and of puparia found to be free of the same. The "not parasitized" samples of all the three lots, A, B, and C exhibit greater ranges in form than do those affected by the endoparasites, showing again that endoparasites have a retarding effect on the size of the puparia.

Other factors related to variation in length. While rose hosts and parasites appeared to be the dominant causes of variation in these samples of puparia of *Rhag. basiola*, they are quite certainly not always the sole, nor even the major factors.

As stated above, the absence of parasites in the instance of *Rosa palustris* at Urbana clearly favored the record large size of the puparia, and it is very likely that other adverse influences supplemented the parasites in the production of the inordinately small puparia in Minnesota and Wisconsin. Evidence of three such supporting factors came to my notice in the latter areas between 1945 and 1951.

One significant influence observed repeatedly at Eaglesnest, Minnesota, concerned the inherent bony hardness of the unripe hips of *Rosa blanda*. This texture of the hypanthium frequently thwarted *Rhag. basiola* in her efforts to prepare pits for the reception of eggs, and also often rendered the establishment and feeding of the first instars difficult, with the result that some surviving individuals did not attain normal size and consequently became puparia of meager length.

Again, eggs of the rose hip fly may be inserted into over-ripe hips, particularly in late summer. As a consequence, the larvae may be obliged to complete their advanced instars by feeding on deteriorating hypanthium, and are therefore undernourished and develop to undersized puparia. Some of the smallest puparia I have seen occurred under such conditions in hip jars in October. Dissection showed that some such small individuals contained no parasites, hence their reduced size was probably often attributable to their meager food.

Thirdly, it is very probable that the advent of drought conditions, which prevailed late in some summers, and particularly in the area of Chetek, Wisconsin, caused high percents of the hips of *R. blanda* and *carolina* to shrivel and toughen. This texture of the hypanthium rendered feeding by the larvae difficult, with the result that individuals, which barely attained maturity, eventuated as undersized puparia. While *Halticoptera* and *Opius* occurred here, they did not affect all the small puparia. This fact indicates that drying hips alone are significant factors in determining size of the insects inhabiting them.

Complexes of factors.—From the above consideration of environmental factors, it becomes apparent that climatic and biotic influences contribute to variation in the length of the puparia of *Rhag. basiola*. Moreover, it is clear that the factors do not operate only as individuals but largely as complexes. Among these associated influences generally occur both positive and negative types which, by their inherent contradictory nature, work counter to one another. These conflicts tend to prevent any one factor from exerting its full influence, either to produce puparia of exceptionally large, or small, size. This fact is indicated in Class I, defined above, whose "majorities" embraced puparia of average lengths, *i.e.*, 4.0 to 5.49 mm., and, moreover, contained 93 percent of all the puparia involved in this study.

The data pertaining to this investigation indicate further that the several components, such as rose hosts, parasites and drought, obviously vary in the magnitude of their influences from place to place and from year to year. Under some kinds of environmental conditions, certain factors, for example *Rosa palustris* and the parasites, *Halticoptera* and *Opius*, exert major controls over length. However, in other times and places, rose hosts and parasites perform at various reduced levels of effectiveness.

This principle of fluctuating influence was illustrated in northeastern Minnesota in the decade of 1943–1953. Dissections of larvae and puparia of *Rhag. basiola* revealed that both *Halticoptera* and *Opius* sank to low levels of performance in some of the years, while in others, one or other of them attacked almost 100 percent of the host samples examined.

SUMMARY

The puparia of *Rhagoletis basiola* are subject to wide variation in length and form. Length varied from 3.0 to 6.9 mm., form from a ratio of 1.77:1.00 to 3.75:1.00. Length and form are merely two ways of stating the amount of variation. Form, *i. e.*, ratio of length to diameter, has the effect of minimizing length values, and therefore is less desirable as a method of expressing variation. Ac-

cordingly, form also has less value as an indicator or identifier of the causal factors of variation.

Factors identified as causes in this study are ecological, and both climatic and biotic. Drought may indirectly influence the size of puparia through its adverse effects on the hips and the contained growing larvae. Biotic factors instrumental as determinants of size include (1) bony texture and (2) deteriorated condition of the hypanthium inhabited by the larvae, (3) the size of the hip, or quantity of food available to the larvae, (4) its content of vitamin C, and (5) the hymenopterous parasites, *Halticoptera* and *Opius*. Of these factors, the parasites exert the most decisive effect on the size of the puparia.

Biogeography. *Pierre Dansereau.* The Ronald Press. xiii + 394 pp. $7.50. 4-17-57.

Biogeography has as its domain the fields of plant and animal ecology and geography, with many overlaps into genetics, human geography, anthropology, and the social sciences. The author (a botanist) having taught at the Universities of Montreal, Brazil, and Michigan, has provided this new synthesis of the environmental relationships of organisms for senior and graduate students, and hopes that it may serve as an ecological inventory for natural scientists, social scientists and geographers.

The author states that he has attempted to show "some of the many ways in which living organisms are adapted and to provide a review of the kinds of environment and the variety of responses" within "the framework of a consistent ecological approach and methodology."

In his Introduction, Dr. Dansereau states his concept of five levels of integration (historical, bioclimatological, synecological, antecological, and industrial) and his plan for recording seven types of information for each level. A brief statement presents the problem of linking together the processes of heredity and environment, *i.e.*, the phylogenetic processes (mutation, ploid variation, and hybridization), and the environmental processes (climatogenic, pedogenic, and biogenic).

The author's experiences from Arctic to South of the equator, in Eastern and Western hemispheres, and his knowledge of languages have enabled him to present broad concepts with excellent illustrations. The bibliography is extensive and the index is good. A Glossary is included because "technical vocabulary is not deliberately avoided."

THOMAS H. LANGLOIS

The Fishes of Ohio. *Milton B. Trautman.* Ohio State University Press. xvii + 683 pp. $6.50.

This fine book puts Ohio in the foreground of the states whose fishes have been listed and described. Not since 1920, when the book of Illinois fishes became available, have scientists had access to such excellent data on distribution, combined with means for identification. All of the 172 kinds of fishes are portrayed by drawings, and each kind has its places of collection shown on an individual map.

The format is especially fine for use in laboratory and office, and the high quality paper reproduces well the details of drawings and maps. The accuracy of the drawings, possible only because of the author's knowledge of the characters of each kind of fish, will be of value to scientists. The author states that hand-lens, dividers, and scalpel will be needed to work the keys to families, genera, species and sub-species. Closely related forms have been combined in certain genera, such as *Noturus*, *Coregonus*, *Percina*, *Etheostoma*, and *Hiodon*, thus eliminating several names which the author considers invalid in frequent usage.

The seven color plates make available for the first time some paintings made in 1930 by Mrs. Green, the artist who illustrated "The Fishes of Illinois." The literature cited is extensive, and the index is good.

The Ohio State University Press has inaugurated its new life with a significant book, and the Ohio State University Development Fund, and the Ohio Division of Wildlife are to be complimented for their allocation of funds to underwrite this publication.

THOMAS H. LANGLOIS

NOTES ON THE HEPATIC FLORA OF THE ATHENS AREA

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In comparison with the hepatic flora of many adjacent states, that of Ohio has received relatively little attention. Since 1953, the writer has collected extensively in southeastern Ohio, chiefly in the neighborhood of Athens. Apparently no records of any liverworts from this area have been published. This report attempts to summarize all collections from the area up to the present.

An unpublished thesis by McCleary (1946) deals chiefly with mosses but furnishes authenticated records of 10 hepatics. Prescher (1946) collected approximately 38 species from Athens Township. The total reported was higher but unfortunately has been reduced by misidentified or unsatisfactory material.

Fifty-eight species, supported by specimens, are recorded at present. Substrate as observed in the area, relative abundance, and one collection from Athens County are cited for each. Records from neighboring Meigs and eastern Vinton County, which were included in this study, are appended. The writer's collections are referred to merely by collection number; those of others by collector and date. All specimens cited are deposited in the Ohio University Herbarium in Athens.

Liverworts are almost universally less common and occupy a narrower spectrum of habitats than mosses. The unglaciated hill country of southeastern Ohio is quite favorable, however, and comparatively rich in species. Constant moisture of the substrate and of the air is required by most liverworts, and damp, coarse-grained sandstone in rich, shady ravines is the outstanding hepatic habitat in the Athens area. Only a few species venture into relatively dry, exposed situations.

Ptilidiaceae

Ptilidium pulcherrimum (Web.) Hampe. On dry sandstone, sometimes decaying logs. Several collections, all from the East Hill area near Athens. Blickle, July 27, 1946, Sec. 3–4, Athens Twp.

Blepharostoma trichopyllum (L.) Dumort. On moist sandstone. Uncommon. *141*, North Hill Caves near Athens.

Trichocolea tomentella (Ehrh.) Dumort. On moist sandstone and adjacent humus. Uncommon. *287*, Waterloo Game Preserve.

Lepidoziaceae

Bazzania denudata (Torrey) Trevis. A single collection, from moist sandstone: *289*, Waterloo Game Preserve.

Bazzania trilobata (L.) S. F. Gray. On moist sandstone, occasionally on adjacent mossy soil. Uncommon. *551*, two miles north of Mineral. Also Vinton County: *2674*, in ravine adjacent to Moonville Tunnel, Brown Twp. This species is much more widespread and luxuriant in the Hocking Caves region to the northwest.

Lepidozia reptans (L.) Dumort. On moist sandstone, sometimes decaying logs. Uncommon. *651*, one-half mile northeast of Carbondale.

Microlepidozia sylvatica (Evans) Joerg. On moist sandstone. Uncommon. *576*, North Hill Caves near Athens. Also Vinton County: *2649*, along Racoon Creek near Arbaugh.

Calypogeiaceae

Calypogeia trichomanis (L.) Corda. Chiefly on moist sandstone overhangs. Common. *649*, one-half mile northeast of Carbondale. Also Vinton County: *2962A*, near Piney Point of Lake Hope; Meigs County: *152*, near junction of Rte. 33 and Kingsbury Creek.

Cephaloziaceae

Cephalozia bicuspidata (L.) Dumort. On moist sandstone, sometimes soil. Rather common. *190*, Waterloo State Forest.

Cephalozia media Lindb. On moist sandstone, sometimes soil. Rather common. *119*, North Hill Caves near Athens.

Norwellia curvifolia (Dicks) Mitt. On moist decorticated logs, less frequently on sandstone. Rather common. *611*, Stroud's Run, Canaan Twp. Also Vinton County: *2690*, near Piney Point of Lake Hope.

Odontoschisma denudatum (Mart.) Dumort. A single collection, from a decaying stump: Blickle, July 27, 1946, Sec. 32–33, Athens Twp.

Odontoschisma prostratum (Sw.) Trevis. On moist sandstone, sometimes mossy soil. Uncommon. *517*, Birch Hollow near Carbondale. Also Vinton County: *2675*, in ravine adjacent to Moonville Tunnel, Brown Twp.

Harpanthaceae

Lophocolea alata Mitt. On moist sandstone. Rare. *675*, Waterloo State Forest.

Lophocolea heterophylla (Schrad.) Dumort. On wood, rocks, and soil. Quite common and widespread. *584*, Burr Oak Lake, Trimble Twp.

Chiloscyphus pallescens (Ehrh.) Dumort. On moist rotting wood, soil, and sandstone. A few collections from Athens Twp. *683*, Dobson's Hollow near Athens.

Chiloscyphus polyanthus (L.) Corda. A single collection, from moist soil: Prescher, June 20, 1946, Sec. 9–10–16, Athens Twp.

Geocalyx graveolens (Schrad.) Nees. On moist sandstone. Rather common. *503*, Birch Hollow near Carbondale. Also Vinton County: *2648*, along Raccoon Creek near Arbaugh.

Jungermanniaceae

Lophozia incisa (Schrad.) Dumort. In mats of *Cephalozia* on moist sandstone. Several collections, all from Athens Twp. *279*, North Hill Caves near Athens.

Jungermannia lanceolata L. On moist sandstone. Several collections, all from Rome Twp. *2272C*, just south of Broadwell.

Jungermannia pumila With. A single scanty collection, from moist sandstone: Prescher, July 2, 1946, Sec. 5–6–12, Athens Twp.

Jamesoniella autumnalis (DC.) Steph. On fairly dry sandstone. Common. *652*, one-half mile northeast of Carbondale. Also Vinton County: *2662*, Lake Hope State Park.

Nardia lescurii (Aust.) Underw. One scanty collection, probably this species, from moist sandstone: Blickle, June 28, 1946, Sec. 32–33, Athens Twp.

Plectocolea crenulata (Smith) Evans. A single collection, from an exposed clay bank: *581*, North Hill Caves near Athens.

Plectocolea crenuliformis (Aust.) Mitt. A single collection, from moist sandstone: Prescher, July 2, 1946, Sec. 5–6–12, Athens Twp.

Plectocolea hyalina (Lyell) Mitt. On moist sandstone. Rather common. *158*, along Rte. 33 near West Branch of Shade River, Lodi Twp.

Plagiochilaceae

Plagiochila asplenioides (L.) Dumort. Chiefly on moist sandstone. Quite common and widespread. *663*, along Rockcamp Creek, Waterloo Twp. Also Vinton County: *2691*, near Piney Point of Lake Hope; Meigs County: *2639*, Forked Run State Park.

Scapaniaceae

Diplophyllum apiculatum (Evans) Steph. Chiefly on moist sandstone. Rather common. *121*, North Hill Caves near Athens. Also Vinton County: *2676*, in ravine adjacent to Moonville Tunnel, Brown Twp.

Scapania nemorosa (L.) Dumort. Chiefly on moist sandstone. Quite common and widespread. *227*, two miles west of Broadwell. Also Vinton County: *2692*, near Piney Point of Lake Hope.

Scapania undulata (L.) Dumort. On wet or submerged sandstone. Uncommon. *687*, in Long Run southeast of Athens.

Porellaceae

Porella pinnata L. On moist sandstone adjacent to waterfalls. Apparently rare. *211*, Crumley's Run, Canaan Twp.

Porella platyphylla (L.) Lindb. [including *P. platyphylloidea* (Schwein.) Lindb.] On sandstone, limestone, tree bases, and decaying logs, chiefly along streams. Quite common and widespread. *648*, one-half mile northeast of Carbondale. Also Vinton County: *2685*, Lake Hope State Park.

Radulaceae

Radula complanata (L.) Dumort. On sandstone, sometimes limestone. Fairly common. *634*, near Concord Church, Ames Twp.

Radula obconica Sulliv. On moist sandstone, often growing over rootlets and other bryophytes; sometimes tree trunks. Fairly common. *637*, along Rte. 56 opposite the Waterloo Game Preserve. Also Vinton County: *2632*, Vinton Furnace Experimental Forest; Meigs County: *738*, Forked Run State Park.

Frullaniaceae

Frullania asa-grayana Mont. On dry sandstone. Rather common. *639*, on Rte. 56 opposite the Waterloo Game Preserve. Also Meigs County: *2636*, Forked Run State Park.

Frullania brittoniae Evans. On dry sandstone and tree trunks. Common. *2272A*, along Rte. 329, Rome Twp.

Frullania eboracensis Gottsche. On tree bark and probably rocks. Probably fairly common. Prescher, June 21, 1946, Sec. 29–30, Athens Twp.

Frullania plana Sulliv. A single collection, from moist sandstone: *2615*, Stroud's Run, Canaan Twp.

Frullania riparia Hampe. On moist sandstone, possibly indicating the presence of lime, and tree bases. Uncommon. *213*, Crumley's Run, Canaan Twp. Also Vinton County: *2673*, near town of Hope.

Jubula pennsylvanica (Steph.) Evans. On moist sandstone. Fairly common. *575*, North Hill Caves near Athens. Also Meigs County: *2272*, Forked Run State Park.

Lejeuneaceae

Leucolejeunea clypeata (Schwein.) Evans. On rather dry sandstone, sometimes tree bark. Fairly common. Prescher, June 24, 1946, Sec. 29–30, Athens Twp. Also Vinton County: *638*, along Raccoon Creek near Moonville; Meigs County: *2640*, Forked Run State Park.

Cololejeunea biddlecomiae (Aust.) Evans. On fairly dry to moist sandstone and bark, frequently on mosses. Common. *658*, along McDougall Branch, Ames Twp. Also Vinton County: *2688*, Lake Hope State Park.

Fossombroniaceae

Fossombronia wondraczeki (Corda) Dumort. On moist exposed soil. Fairly common. *605*, near Buchtel Buffalo Beat.

Pelliaceae

Pellia epiphylla (L.) Corda. On moist sandstone and exposed soil. Common. *124*, North Hill Caves near Athens. Also Vinton County: *2633*, along Elk Fork, Vinton Furnace Experimental Forest.

Blasiaceae

Blasia pusilla L. A single collection, from wet clayey banks of stream: Prescher, July 11, 1946, Sec. 1–2–7, Athens Twp.

Pallaviciniaceae

Pallavicinia lyellii (Hook.) S. F. Gray. On wet rotting wood, soil, and among other bryophytes on sandstone. Uncommon. *643*, one-half mile northeast of Carbondale. The species is much more plentiful in peat bogs elsewhere in Ohio.

Metzgeriaceae

Metzgeria conjugata Lindb. Chiefly on moist sandstone. Fairly common. *2614*, Stroud's Run, Canaan Twp. Also Meigs County: *2637*, Forked Run State Park.

Riccardiaceae

Riccardia multifida (L.) S. F. Gray. A single sterile collection, probably this species, from a tree base: Blickle, September, 1953, one mile east of Athens.

Riccardia pinguis (L.) S. F. Gray. On sandstone and moist rotting wood. Uncommon. *516*, Waterloo Game Preserve. Also Vinton County: *2635*, Vinton Furnace Experimental Forest.

Marchantiaceae

Marchantia polymorpha L. On wet soil. A few old collections from Athens Township from stations now apparently destroyed. Prescher, June 21, 1946, Sec. 9–10–16, Athens Twp.

Preissia quadrata (Scop.) Nees. A single collection, from a moist sandstone face: Robinson & Blickle, March 24, 1954, two miles south of Broadwell.

Conocephalum conicum (L.) Dumort. On moist sandstone and soil. Quite common and widespread. *610*, Stroud's Run, Canaan Twp. Also Vinton County: *2661*, Lake Hope State Park; Meigs County: *2641*, Forked Run State Park.

Rebouliaceae

Reboulia hemisphaerica (L.) Raddi. On moist sandstone and soil. Uncommon. *512*, Waterloo Game Preserve.

Asterella tenella (L.) Beauv. On moist soil. Uncommon. Robinson, March 11, 1955, Carbondale Forest, York Twp.

Ricciaceae

Ricciocarpus natans (L.) Corda. A single collection, from a stagnant pond: *2647*, remains of old Hocking Canal north of Armitage. A few sterile thalli of *Riccia* sp. have been observed on a muddy bank of the Hocking River near Athens.

Anthocerotaceae

Anthoceros laevis L. On moist exposed soil and sandstone. Common. *216*, Athens State Hospital grounds.

Anthoceros punctatus L. A single collection, from a moist streambank: Prescher, July 11, 1946, Sec. 1–2–7, Athens Twp.

Notothylas orbicularis (Schwein.) Sulliv. Collected at a single station: *589*, on moist exposed soil in wet meadow trampled by cattle, Waterloo Game Preserve; probably in similar situations elsewhere.

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A readable assembly of an amazing quantity of facts about the distribution of land vertebrates and fresh-water vertebrates over the world, presented as the basis for the author's understanding of the main pattern of animal distribution and his conclusions as to how and why this pattern has been formed and what it tells about ancient land and climates.

Darlington (a taxonomist) enumerates a series of working principles for zoogeographers. For example, animals are tending both to multiply and spread and to die and lose ground, and the centers of evolution and dispersal are also likely to be centers of extinction. When working out the histories of families, simple clues should be distrusted because of the possible complexity of geographical movements. Patterns of distribution are changing constantly, and clues to geographical histories must be understood and used fairly. When facts fail, working hypotheses must be used, because science proceeds by defining problems and trying to solve them.

Sections are devoted in sequence to the several orders of vertebrates, *i.e.* fishes, amphibians, reptiles, birds and mammals, and these are followed by a section in which five patterns of distribution are combined into a common continental pattern, and in which the world is divided into faunal regions. Separate consideration is given to the nature, distribution and significance of the vertebrates of islands. The last quarter of the book is allocated to discussions of the evolution of the geographical patterns, the geologic past, and man.

Darlington states an important principle of zoogeography in his consideration of the reasons why man's ancestors came down from the trees, left the forest and began to pursue game in open country, as follows (p. 627).

"It seems to be a principle of zoogeography that movements of animals into new places are usually not escapes but spreadings of dominant groups to obtain new advantages.". . . ."If our ancestors had put safety first, they could have stayed in the trees. Some potential ancestors did so and are apes today. But from the very beginning the apes that became men probably ran after what they wanted more than away from what they feared."

From this point of view the author draws a highly significant conclusion (p. 645). "Any large group of people can now, if they wish, draw ideas from the whole world and combine them with their own ideas to make better ones. The people who do this best, and who remember the old lesson that gains are more important than escapes (although escapes are important too) will probably hold or take power in the future. The people who cut themselves off from ideas, or who sacrifice gains to temporary security, will not hold power long. This, I think, is the plain lesson of the history of evolution and dispersal of animals and of man himself."

THOMAS H. LANGLOIS

STUDIES CONCERNING THE ACTION OF BISULFITE SOLUTIONS ON THE WHITE MOLD (*PENICILLIUM* AND *ASPERGILLUS* SP.P.) ISOLATED FROM AILING GRASS SILAGE

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INTRODUCTION

The production of good silage is automatic when all the requirements are satisfied at silo filling time. It often happens that the factors affecting the silage formation are not completely under control. Most trouble arises from the custom filling of silos. The equipment comes too late when the grasses are past their prime, or the operator rushes through the work leaving an ailing silage which heats and molds, faster than it can be fed. This is characteristic of too loosely packed silages because the air is not kept out.

Changes also occur in a well ensiled crop. The causes (Barnett, 1954) can be stated as: a. The continued respiration of the plant cells in the silage, giving off CO_2 and water, accompanied by heat evolution; b. production of acetic acid by Coliform bacteria which are destroyed by the heat developed in the early state of fermentation (These two stages have short duration and are completed in three days.); c. the lactic acid formation by the activity of lacto bacilli and streptococci on the available carbohydrates. These bacteria are more heat resistant. d. The fourth stage is the continuous formation of lactic acid which persists for 17 to 21 days. e. If not enough lactic acid is formed, *Clostridium butyricum* with *Clostridium welchii* attacks the lactic acid system, forming butyric acid (Barnett, 1954). These organisms are present in grass and soil and can be controlled by a pH of 4.2 or below (McCoy *et al.*, 1930). Butyric acid in different concentrations (Barnett and Miller, 1951) is relished by sheep. When in greater concentration this may be associated with a considerable degree of proteolysis with the formation of amides and ammonia which are not eaten well by ruminants. Similarly, molds (*Penicillia* sp.p. and *Aspergillae* sp.p.) which are characteristic of bad silage bring about proteolysis and ammonia production (Barnett, 1954) with heat evolution.

In 1952, Cowan, Bratzler and Swift announced the use of sodium metabisulfite instead of sulfur dioxide for the preservation of chopped grasses and corn.

The authors of the present paper carried out the study of the action of the bisulfite solutions on pure culture of white mold isolated from old dry silage and report in the experimental section which follows.

EXPERIMENTAL PROCEDURE AND RESULTS

The stock solutions of the following concentrations were prepared and were added to 15 ml. volume of the warm Sabouraud's agar medium according to tables

1. 1.25 percent sodium metabisulfite, alone.
2. 0.7 percent sodium metabisulfite and 0.7 percent lactic acid. Equal volumes were mixed.
3. 5.0 percent lactic acid, alone.
4. 2.5 percent sodium metabisulfite and 2.5 percent sodium lactate. Equal volumes were mixed, bringing the concentration to 1.25 percent of each.

These concentrations were experimentally determined in advance so that they would fall in the range of their reactivity. The salt solutions were well mixed with the agar media to avoid layering before inoculation which may be disastrous on the spores transferred. The mixing was accomplished by quickly turning the test tubes, with the cotton plugs in, upside down several times. The agar media were kept at 55° C in a water bath while the stock solutions were at room temperature, 70° C, before mixing. Each tube was inoculated with .2 ml. of spores suspended in broth.

TABLE 1

The effect of 1.25% sodium metabisulfite concentrations and pH on the growth of molds of Penicillium *and* Aspergillus sp.p.

Volume in ml. of $Na_2S_2O_5$ added to 15 ml. Agar Media	Conc. of $Na_2S_2O_5$ in grams per L in Nutrient Agar Media	Osmotic Pressure in Atmospheres	Effect of Growth of Molds. No. of Colonies per 65 sq. cm.	pH
4	2.63	1.24	0	5.1
3	2.08	0.98	0	5.1
2	1.47	0.69	0	5.1
1.5	1.14	0.53	0	5.15
1.0	0.78	0.36	35	5.15
.75	0.59	0.27	65	5.2
.50	0.40	0.18	450	5.2
0.	0	0	500	5.2

TABLE 2

The combined effect of 0.7% sodium metabisulfite and 0.7% lactic acid concentration and pH on the growth of molds of Penicillium *and* Aspergillus sp. p.

Volume in ml. of $Na_2S_2O_5$ Added to 15 ml. Agar Media	Volume in ml. of Lactic acid Added to 15 ml. Agar Media	Ratio of Conc. of $Na_2S_2O_5$ and Lactic Acid in g/liter in Nutrient Agar Media	Total Osomotic Pressure in Atmospheres	Effect on Growth of Molds. No. of Colonies per 65 sq cm.	pH
2 ml.	2 ml.	0.74/0.74	0.52	0	4.3
1.5	1.5	0.60/0.60	0.42	0	4.45
1.0	1.0	0.41/0.41	0.29	4	4.6
.75	.75	0.32/0.32	0.23	120	4.7
.5	.5	0.22/0.22	0.15	500	4.9
.375	.375	0.16/0.16	0.11	500	5.0
.25	.25	0.11/0.11	0.08	500	5.1
0.	0.			500	5.2

The molds were isolated from spoiled silage by standard methods and grown on standard Sabouraud's agar media. The mold colonies appeared between 20 and 48 hours. Beyond this time no increase of colony-number occurred but an increase of colony-size took place. The number of colonies is taken as a measure of the effectiveness of the additive agents.

In bacteriological work, any mold contamination covers up bacterial growth by its quick development. Because molds were studied in this experiment, the slower development of any bacteria would be unlikely to affect the observation. Until the mold colonies grew together, the agar media stayed clear, free of bacteria growth. We considered the technique not perfect but adequate.

This study follows three lines of investigation: (1) toxic effect of these additive agents, (2) plasmolytic effect, and (3) pH.

Table 1 shows the effect of sodium metabisulfite alone. The lowest inhibiting concentration is 1.14 g 1. Decreasing concentration of metabisulfite results in increasing number of mold colonies.

Table 2 gives the toxic effect of sodium metabisulfite and lactic acid on the growth of molds. The presence of lactic acid reduces the inhibiting concentration of the metabisulfite from 1.14 g/1 alone in table 1, to 0.60 g 1 in the mixture.

TABLE 3

The effect of 5% lactic acid concentrations and pH on the Growth of molds of Penicillium *and* Aspergillus sp.p

Volume in ml. of Lactic Acid Added to 15 ml. Agar Media	Conc. of Lactic Acid in g/L in Nutrient Agar Media	Osmotic Pressure in Atmospheres	Effect on Growth of Molds. No. of Colonies per 65 sq. cm.	pH
4	10.5	2.60	0	2.95
3	8.33	2.08	0	3.05
2	5.88	1.48	0.6	3.2
1.5	4.54	1.13	500	3.55
1.0	3.13	0.78	500	3.6
.75	2.38	0.59	500	3.75
.50	1.61	0.40	500	4.0
0	0	0	500	5.2

TABLE 4

The combined effect of 2.5% sodium metabisulfite and 2.5% sodium lactate concentrations and pH on growth of the molds of Penicillium *and* Aspergillus sp. p.

Volume in ml. $Na_2S_2O_5$ Added to 15 ml. Agar Medium	Sodium Lactate Added to 15 ml. Agar Medium	Ratio of Conc. of $Na_2S_2O_5$ and Sodium Lactate in g/L in Nutrient Agar Media	Osmotic Pressure in Atmospheres	Effect of Growth of Molds. No. of Colonies per 65 sq. cm.	pH
2 ml.	2 ml.	2.63/2.63	2.23	0	5.45
1.5	1.5	2.08/2.08	1.79	0	5.4
1.0	1.0	1.47/1.47	1.26	0	5.4
.75	.75	1.14/1.14	0.98	0	5.35
.50	.50	0.78/0.78	0.67	0	5.3
.375	.375	0.60/0.60	0.51	5	5.3
.25	.25	0.40/0.40	0.34	80	5.3
0	0	0	0	500	5.2

Table 3 gives the toxic effect of lactic acid alone. Here a concentration of 8.33 g/1 is required to inhibit mold growth completely.

Table 4 gives the toxic effect of sodium metabisulfite and sodium lactate. Here only 0.78 g 1 sodium metabisulfite are required to reach the inhibiting level. This is lower than that of sodium metabisulfite alone, (1.14 g 1) in table 1, but slightly higher concentration than that found in table 2 in which lactic acid is also present. Obviously, therefore, the combined effect of sodium metabisulfite and lactic acid is superior to the others.

The superior toxic effect of the combined solutions of sodium metabisulfite and lactic acid could be interpreted by the following chemical reactions.

(1) The change of one mole of sodium metabisulfite to two moles of sodium bisulfite. $Na_2S_2O_5+H_2O \rightarrow 2\ NaHSO_3$

(2) The reaction of two moles of sodium bisulfite with two moles of lactic acid forming two moles of sodium lactate and one mole of sulfurous acid. The solubility of all the components in water points to the possibility of a reversible reaction as given below:

$$2\ NaHSO_3+2\ HO-\overset{\overset{O}{\|}}{C}-CHOH-CH_3 \rightleftarrows 2NaO-\overset{\overset{O}{\|}}{C}-CHOH-CH_3+H_2SO_3$$

This indicates the presence of sulfurous acid in the chemical equilibrium.

Mixing equivalent sodium bisulfite and lactic acid produces a solution in which the bisulfite and the lactic acid are in ionic equilibrium with sodium lactate and sulfurous acid. This equilibrium is disturbed by any changes of any of the components of the solutions. Thus, H_2SO_3 decomposes into H_2O and SO_2 which may later disappear. Any other change of the sulfur compound may affect the reserve supply of biologically effective sulfur compounds.

In addition to the toxic effect of the stock solutions, a plasmolytic effect of these solutions was also considered. Osmotic pressure of 2.08 in atmospheres was taken as a threshold as shown in table 3, lactic acid alone, to be the minimum osmotic pressure to completely inhibit the growth of the molds. It is noted that all the other thresholds in tables 1, 0.53; 2, 0.42; and 4, 0.67 are far below this value. This may exclude the possibility that the inhibiting effect was caused by plasmolysis. These calculations are based only on the stock solutions added, not including the osmotic pressure of standard agar media.

The pH values were determined electrometrically with a glass electrode.

Alderman *et al.* (1955) in their discussion about bisulfite silages, attributed the preservative effect not to the H^+ion concentration as it was emphasized in the preparation of acid silages, but rather to the toxic effect of HSO_3^- ion. Rahn and Conn (1944), who studied the toxicity of ions received in the first and second steps of ionization of sulfurous acid, reported higher toxicity for the HSO_3^- ion and lower for the $SO_3^=$ ion. They reported the maximum concentration of HSO_3^- ions was obtained between pH 3.0 and 4.0. Even at pH 5.0, the concentration of HSO_3^- ions was 67 percent of the sulfurous acid present. These data of Rahn and Conn are in accord with pH measurement as reported in tables 1 and 2. In table 1, the pH values changed from 5.2 to 5.1 with increasing concentrations of the metabisulfite. In table 2, the pH values changed from 5.2 to 4.3 with increasing concentration of the mixture of sodium metabisulfite and lactic acid. In table 3, the pH values for different concentrations of lactic acid are given. In table 4, there was observed a slight increase in pH with increasing sodium metabisulfite and sodium lactate concentrations, for which a possible explanation could be the alkaline hydrolysis of sodium lactate. The increase in toxicity in table 4 over sodium metabisulfite alone, as shown in table 1, would indicate a potentiation of the sodium bisulfite by the presence of lactate.

Comparing the inhibiting concentrations of sodium bisulfite in grams per liter, that is, the lowest concentrations which inhibit mold growth completely, are given in:

Table 1 1.14 g/l sodium bisulfite alone.
Table 4 0.78 g/l sodium bisulfite and sodium lactate together.
Table 2 0.60 g/l sodium bisulfite and lactic acid together.

The components of table 2 indicate the most effective agents for inhibiting the molds in question.

SUMMARY

Two types of molds were used in the test, *Penicillium* sp.p. and *Aspergillus* sp.p. The different ratios of sodium metabisulfite, lactic acid and sodium lactate have been experimentally determined. Sodium lactate has been found to increase the toxic effect of sodium metabisulfite but not as much as lactic acid. The combined toxic effect of sodium metabisulfite and lactic acid was superior to the others.

Concerning the hydrogen ion concentration, it was observed there was very little change in tables 1 and 4; in table 2 there was a ten fold increase; whereas in table 3 there was a hundred fold increase in the hydrogen ion concentration in column five.

When the acidity of the medium is approximately the same as that of the agar solution, the bisulifite alone is less effective than a mixture of bisulfite and sodium lactate.

Without bisulfite, the acidity by lactic acid must be about a hundred times that of the agar to inhibit mold growth.

Lactic acid and bisulfite in approximately equal molecular mixture effectively inhibit the mold growth at slightly more than half the concentration of bisulfite required without acid, with an increase in hydrogen ion concentration less than six fold.

ACKNOWLEDGMENT

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Elastic Waves in Layered Media. *W. Maurice Ewing, Wenceslas S. Jardetzky,* and *Frank Press.* McGraw-Hill Book Company, Inc., New York. Lamont Geological Observatory Contribution No. 189. First edition, 1957. xi+380 pp. $10.00.

Theoretical and experimental analyses of earthquake and model seismology, and of the propagation of underwater sound have been assembled in this volume by a research team of three outstanding geophysicists. They have drawn not only from their own research, but also from the work of many others; happily, mathematical relations have been expressed in uniform notation and illustrations.

Many seismologists and engineers will use this book as a desk reference. Its effective use as a text will probably be limited to graduate students in geophysics or engineering. Some geologists, aided by Chapter 1 (Fundamental Equations and Solutions), several chapter introductions, and a good library, may derive considerable benefit from studying this work.

It is hoped that later editions will include an expanded index, the present version of which seems to slight some very useful subject references; the first page of the index lists 52 authors but only 22 subjects.

HOWARD J. PINCUS

THE MICRO-ELEMENT NUTRITION OF *NOSTOC MUSCORUM*

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The Myxophyceae or blue-green algae are the most primitive or least differentiated group of photosynthetic organisms in the plant kingdom. In common with photosynthetic bacteria, they possess neither chloroplasts nor nuclei, and certain species such as *Nostoc muscorum* also are able to fix atmospheric nitrogen (Allison *et. al.*, 1937; Fogg, 1947; Williams and Burris, 1952; Magee and Burris, 1954). It was pointed out by Williams and Burris (1952) that the ability to fix atmospheric nitrogen should be advantageous in the large scale culture of algae intended for use as food.

The macronutrient requirements of blue-green algae have been investigated notably by Chu (1942), Hecker (1950), Gerloff *et al.* (1950, 1952), Allen (1952), Allen and Arnon (1955), and Kratz and Myers (1955). Chu formulated 17 nutrient media for growing different algae, the No. 10 medium being the one most suitable for blue-green algae and the one used in this investigation. Minimum concentrations of essential major elements for optimum yields were obtained for *Coccochloris peniocystis* and *Microcystis aeruginosa* by Gerloff *et al.* (1950, 1952), and they reported that a pH of 10 is optimal.

The essentiality of molybdenum for nitrogen fixation and for assimilation of fixed inorganic nitrogen by *Nostoc* and *Anabaena* was reported by Bortels (1940). The essentiality of boron for the growth of *Nostoc muscorum* was demonstrated by Eyster (1952), and recently Holm-Hansen *et al.* (1954) have shown that cobalt is essential.

The present investigation was undertaken to establish the micronutrient requirements of the blue-green alga, *Nostoc muscorum*. In addition, information was obtained on the levels of concentration at which these various micronutrients become toxic to its growth.

MATERIALS AND METHODS

The strain of *Nostoc muscorum* which was employed in this study was obtained as a pure culture from Drs. Gerloff and Skoog, University of Wisconsin. Precautions were taken to prevent bacterial contamination and cultures which gave a positive test for bacteria with lactose broth were discarded. Cultures were illuminated continuously with flourescent light of 100 f.c. intensity at a temperature of approximately 30° C.

Nutrient solutions having approximately the same content of macronutrients as Chu 10 medium were prepared with spectroscopically pure compounds obtained from Johnson, Matthey and Co., Ltd. (73–83 Hatton Garden, London, England). Since not all of the compounds used by Chu could be obtained in spectroscopically pure form, a modified formula was employed (table 1). The modified Chu No. 10 medium contained all the macronutrient elements, except nitrogen, at the same concentration as recommended by Chu. The nitrogen supply was doubled. The full nitrogen requirement as specified by Chu was supplied as nitrate and an equal amount of ammonium nitrogen (removed from these alkaline cultures during autoclaving) was also included. Boron, manganese and molybdenum were supplied at a concentration of 0.1 p.p.m. unless otherwise stated.

Chu No. 10 medium was also prepared with c.p. grade chemicals for measurements of growth at high levels of all micronutrients. The microelements, other than

TABLE 1

Composition of culture solution used for low level microelement nutrition experiments with Nostoc muscorum

Specpure compound	Grams per liter	P.p.m. of essential elements
$CaCl_2$	(0.98 ml. 1% Ca)[a]	Ca..... 9.8
NH_4NO_3	0.0390	N.....13.6
KH_2PO_4	0.0079	K..... 2.3
		P..... 1.8
KCl	0.0042	K..... 2.2[b]
$MgSO_4 \cdot 7H_2O$	0.0250	Mg..... 2.5
		S..... 3.2
$NaHCO_3$	0.1000	C.....14.3
$FeSO_4 \cdot 7H_2O$	0.00137	Fe..... 0.28
$MnSO_4 \cdot 7H_2O$	0.000504	Mn..... 0.1
H_3BO_3	0.000580	B..... 0.1
$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	0.000184	Mo..... 0.1

[a]Already in solution.
[b]Additional. Total K is 4.5 p.p.m.

TABLE 2

Growth of Nostoc muscorum *at various low levels of each of the four essential micro-elements*

Micro-element	Concentration	Cell count at end of 4 wk.	6 wk.	8 wk.
	p.p.m.	x10⁶/ml.	x10⁶/ml.	x10⁶/ml.
Iron	0	8		
	0.02	17		
	0.04	15		
	0.08	24		
	0.2	23		
	0.4	22		
	1.2	28		
	1.6	22		
	2.0	26		
Manganese	0	4	11	7
	0.001	16	28	36
	0.01	14	36	42
	0.1	8	30	42
	1	12	26	48
	10	9	16	24
Boron	0	19	22	31
	0.001	19	21	34
	0.01	23	27	38
	0.1	20	30	51
	1	23	31	45
	10	11	20	29
Molybdenum	0			23
	4×10^{-8}			46
	4×10^{-7}			27
	4×10^{-6}			33
	4×10^{-5}			45
	4×10^{-4}			54
	4×10^{-3}			64

iron, found to be essential for *Nostoc* in this study were added to the unmodified Chu No. 10 solution to the extent of 0.1 p.p.m.

The conductivity water which was employed in preparing all solutions and media was distilled and was further purified by two passages through a Crystalab Deeminizer (Crystal Research Laboratories, Inc., Hartford 3, Conn.).

TABLE 3

Growth of Nostoc muscorum *at higher than optimal concentrations of each essential micro-element to determine toxic levels*

Micro-element	Concentration	Cell count at end of 4 wk.	Cell count at end of 8 wk.
	p.p.m.	x10⁶/ml.	x10⁶/ml.
Iron	2	33	40
	4	34	45
	6	34	46
	8	37	44
	10	38	45
	20	34	42
	40	20	30
	60	4	5
	80	3	6
	100	1	1
Manganese	1		48
	10	32	46
	20	29	44
	40	23	26
	60	14	21
	80	5	3
	100	3	8
Boron	0.1	37	44
	1	31	50
	10	28	28
	20	25	24
	40	24	28
	60	23	20
	80	17	14
	100	1	6
Molybdenum	0.4	40	54
	2	42	54
	4	44	56
	10	44	48
	20	42	51
	40	38	46
	60	38	49
	80	32	51
	100	42	49
	200	27	
	300	33	
	400	16	
	500	0.1	

The culture vessels were 250-ml. Pyrex Erlenmeyer flasks closed with cotton plugs except those illustrated ones of the iron series which were covered with clean 50-ml. beakers. The volume of the nutrient solution in each flask was 100 ml. The culture flasks were static except for manual shaking usually once daily. Neither air nor CO_2 was bubbled through the flasks. Boron-free Corning flasks were used to establish the essentiality of boron. All glassware was supercleaned by the process of Waring and Werkman (1942) with the following modification.

Between the treatments with alcoholic KOH and with *aqua regia*, the vessels were subjected to 1 percent sodium versenate which has a strong affinity for metal ions. Metals replace sodium in the versenate molecule and are easily removed due to the high solubility of metal-versenate compounds.

After autoclaving, the cooled nutrient solution in each culture flask was inoculated with a loopful of bacteria-free *Nostoc muscorum*. For clear-cut demonstrations of deficiency symptoms, inoculations were made from a culture already

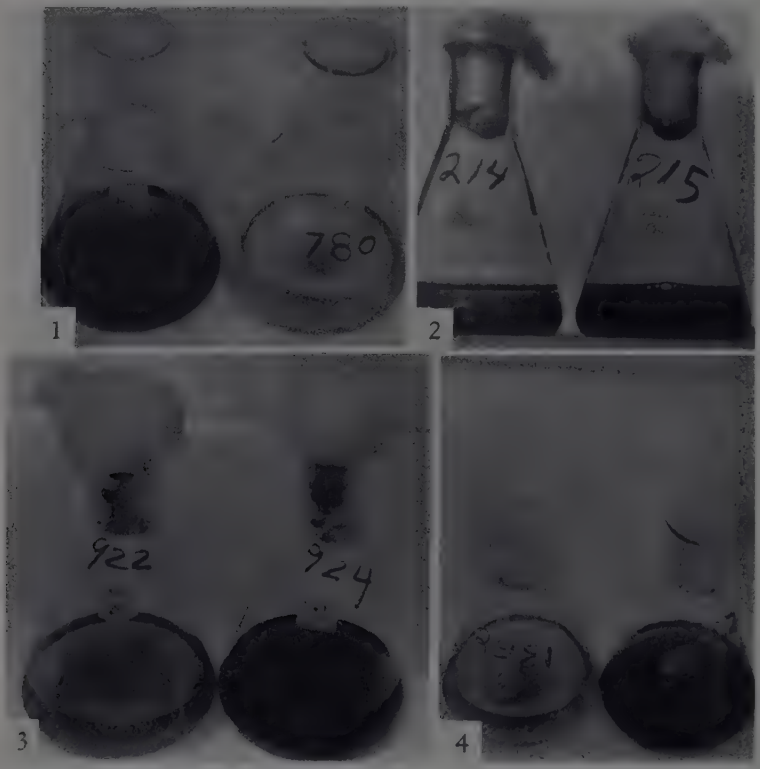

FIGURE 1. Culture on left with iron and culture on right without iron added to the medium.
FIGURE 2. Culture on left without manganese and culture on right with 0.001 p.p.m. manganese added to the medium.
FIGURE 3. Culture on left without boron and culture on right with 0.1 p.p.m. boron added to the medium.
FIGURE 4. Culture on left without molybdenum and culture on right with 0.0004 p.p.m. molybdenum added to the medium.

deficient in the element being studied, and each culture had already been subcultured several times. The boron-deficient series, for example, represented the fifth subculturing from successive two to four-month old boron-deficient cultures. The inoculum cultures distinctly showed the deficiency symptoms and contained no large clumps. It was observed that younger cultures might be somewhat clumped and less homogeneous than older cultures.

Measurements of growth were made by counting cells at the end of 4, 6 and/or 8 weeks. Cultures were brought up to 100-ml. volumes by replacing the evaporated portion with distilled water, and then were poured into a Waring blender to disperse the clumps and homogenize the cultures. Initial blending for two minutes and short blendings before the removal of subsequent samples proved to be adequate for obtaining representative samples. For cell counting a Sedgewick-Rafter algal counting chamber together with a Whipple occular micrometer was used. Five squares, randomly chosen, were counted on each of four samples making a total of twenty counts on each culture. Each sample was required to have a volume of one

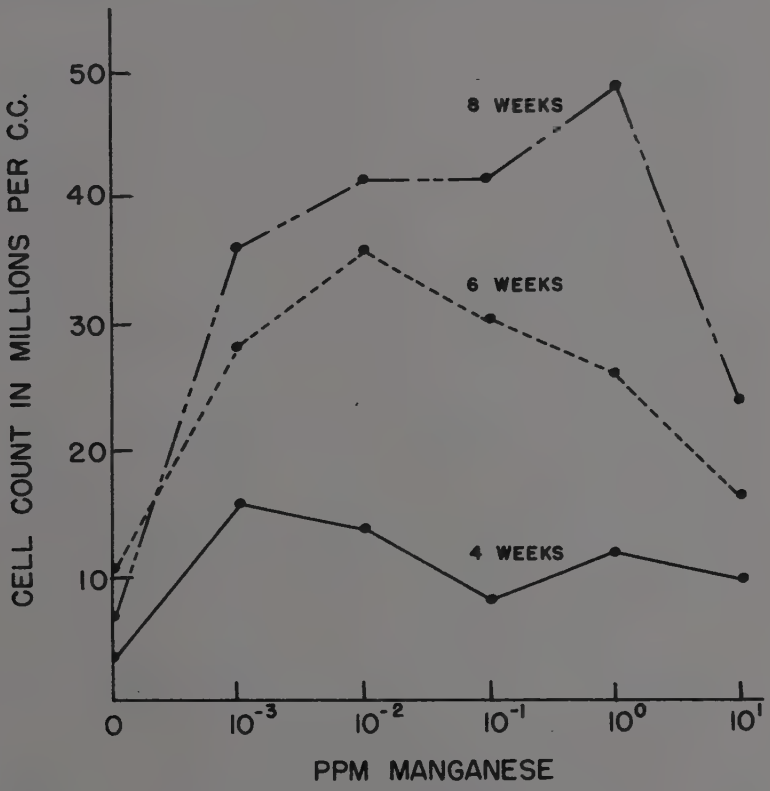

FIGURE 5. Growth of *Nostoc muscorum* at successively higher levels of manganese in the medium.

ml to fill the Sedgewick-Rafter counting chamber. Usually the ml. sample taken directly from the Waring blender was diluted 10 to 20 times, and then a milliliter of this thoroughly mixed dilution was transferred to the counting chamber. Cultures diluted ten times gave direct readings of millions of cells per ml. of the original culture.

RESULTS

It was found that four micronutrient elements are essential to the growth of *Nostoc muscorum*. These elements are iron, manganese, boron and molybdenum. Table 2 presents data on the growth of the alga at various low levels of each of these

elements. At "0" level there was still some growth, but it is assumed that with absolute freedom from the essential micronutrient element there would have been no growth whatsoever. Possible sources of these elements are sub-spectroscopic contamination of the macronutrient "specpure" salts, glassware even though super-cleaned, and the inoculum. It has been shown by Meagher *et al.* (1952) that "normal seeds of some plants may store ten times the total molybdenum needs of the plant to be grown from the seed" and that to show molybdenum essentiality the use of specially grown seeds with low molybdenum content were required.

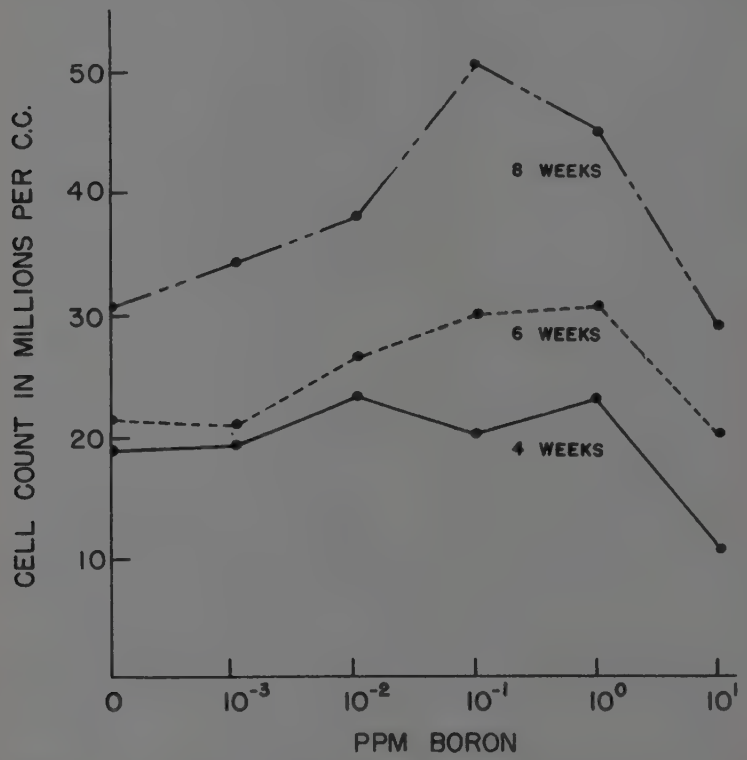

FIGURE 6. Growth of *Nostoc muscorum* at successively higher levels of boron in the medium.

Iron deficiency symptoms (fig. 1) were demonstrated easily even without "specpure" salts and without a subculture inoculum. The data show that the minimum requirement of iron for maximum growth in Chu No. 10 medium was about 0.08 p.p.m. iron, which is only 30 percent of the amount recommended for modified Chu No. 10 medium. C.P. grade ferric chloride was contaminated with manganese so that no manganese deficiency could be demonstrated until a spectroscopically manganese-free source of iron was used. Manganese essentiality is indicated in figures 2 and 5. There were striking differences in densities and cell counts between a culture with "0" manganese and a culture with 0.001 p.p.m.

manganese. The molybdenum requirement for the growth of *Nostoc muscorum* is shown in figures 4 and 7. Boron essentiality is indicated in figures 3 and 6. Cultures with 0.1 p.p.m., boron showed significantly higher cell counts than cultures with "0" boron, which developed extreme chlorosis. Although there was less extreme chlorosis with 0.001 p.p.m. boron than with "0" boron, there was very little difference in the cell counts. Boron-deficient cultures became entirely white

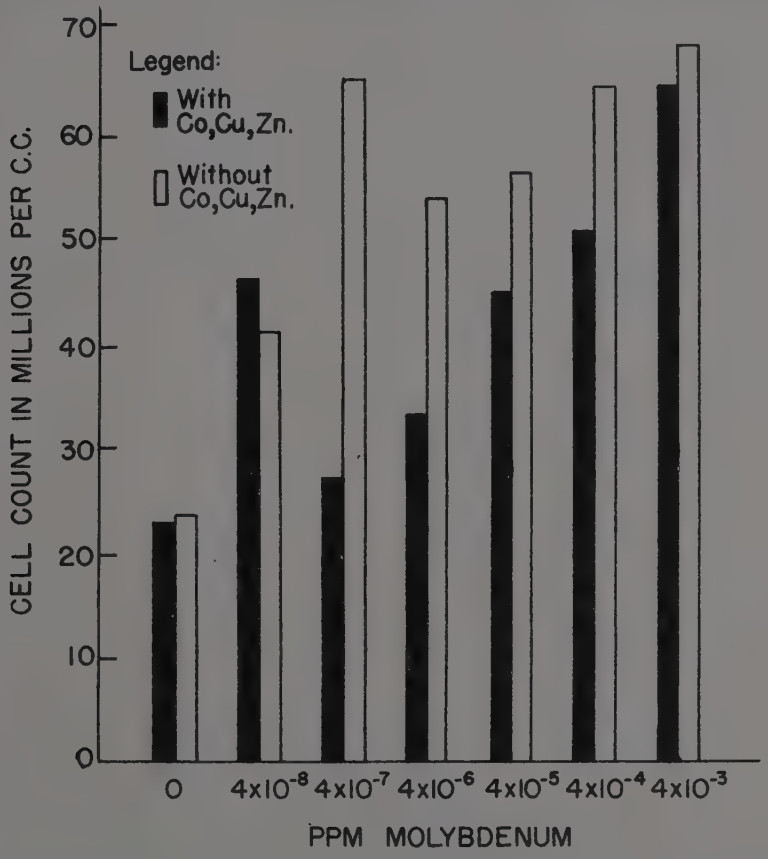

FIGURE 7. Growth of *Nostoc muscorum* at successively higher low levels of molybdenum, comparing growth in the presence of cobalt, copper, and zinc (0.01 p.p.m. of each) with growth in the absence of cobalt, copper and zinc.

as did iron-deficient cultures. Some iron-deficient cultures started out with a blue color changing to white with age. Molybdenum deficiency was characterized by a yellowish-green color, and blue was the characteristic color of manganese-deficient cultures. The term "blue chlorosis" may be used to describe manganese-deficient *Nostoc* cultures.

A molybdenum-copper relationship.—In the presence of cobalt, copper, and zinc (0.01 p.p.m. of each) salts the cell counts of the cultures at various low levels of

molybdenum were consistently lower than similar cultures without cobalt, copper, and zinc (fig. 7). The only exception was at 4×10^{-5} p.p.m. molybdenum. Subsequent cultures with separate additions of cobalt, copper and zinc have shown the effect to be due largely to copper. Molybdenum and copper have previously been found to be reciprocally antagonistic in animal metabolism (Cunningham, 1950). Copper probably competes with molybdenum for a position in the structure of a molybdenum containing enzyme, the active enzyme molecules being the ones containing molybdenum.

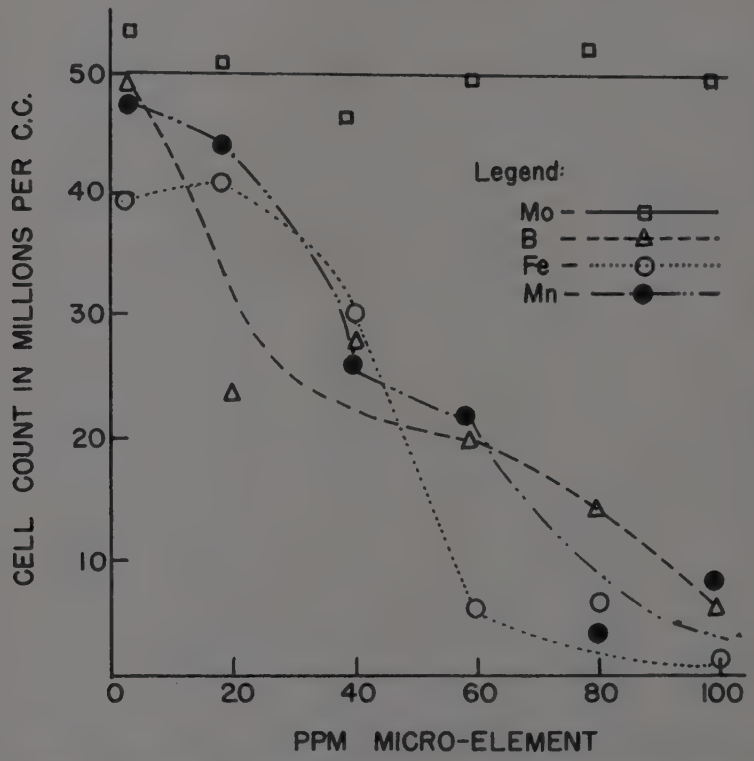

FIGURE 8. Toxic effect on the growth of *Nostoc muscorum* produced by higher than optimal concentrations of molybdenum, boron, iron and manganese, respectively.

Toxicity experiments.—Table 3 and figure 8 present data on the toxicity of the four micronutrient elements. The addition of large amounts of iron and manganese salts caused a shift in the pH, which was adjusted with 0.1 N NaOH to between pH 8.5 and 9.0. Iron showed no toxicity up to 20 p.p.m. as was also the case for manganese. Boron and molybdenum toxicity began at above 1 p.p.m. boron and above 100 p.p.m. molybdenum, respectively. There was almost no growth of *Nostoc muscorum* at 60 p.p.m. iron, 80 p.p.m. manganese, 100 p.p.m. boron, or 500 p.p.m. molybdenum. These were approximate minimum concentrations which inhibited growth almost completely.

SUMMARY

Cultures of *Nostoc muscorum* were grown in Chu No. 10 medium which was prepared with spectroscopically pure compounds. The cultures were illuminated continuously with fluorescent light of 100 f.c. intensity at a temperature of approximately 30° C. The cultures were shaken by hand usually once per day and were neither bubbled with air nor with CO_2 mixed with air. The micronutrient elements found to be essential to the growth of *Nostoc muscorum* were iron, manganese, boron, and molybdenum. Copper was found to interfere with the utilization of molybdenum. Iron showed no toxicity up to 20 p.p.m. as was also the case for manganese. Boron and molybdenum toxicity began at above 1 p.p.m. boron and above 100 p.p.m. molybdenum, respectively. Approximately minimum concentrations which inhibited growth almost completely were 60 p.p.m. iron, 80 p.p.m. manganese, 100 p.p.m. boron or 500 p.p.m. molybdenum.

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IMPURITIES IN HIGH MOLECULAR WEIGHT AMINE PRODUCTS

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The analysis of high molecular weight amines and of such products as the amine acetates is rather difficult, particularly when impurities are to be determined. There are three reasons for the difficulty. First, the amines are complex mixtures obtained from natural products, such as animal and vegetable fats. Thus, they will contain some of the sterols originally present in the fat. Second, the chemical properties of the constituent compounds are rather similar. The probable components can be deduced from a typical commercial method of synthesis (Armour, 1948). This consists of: hydrolysis of the fat, separation of the fatty acid, formation of the amide by reaction with ammonia, dehydration of the amide to form the nitrile, hydrogenation of the nitrile to the amine, and finally the reaction of the amine with acetic acid, if desired. The last step can lead to the formation of N-alkyl acetamides by dehydration of the amine acetate. Thus, in addition to primary, secondary and tertiary amines, we may expect to find nitriles, amides, N-alkylacetamides, and sterols. The third cause of difficulty in analysis is that the high molecular weight amines and their salts are surfactants, with the result that solutions foam to a great extent, and precipitates are frequently kept in suspension. For example, stearic acid will precipatate as lead stearate from 70 percent aqueous acetone upon the addition of lead acetate. However, no precipitate is obtained in the presence of large amounts of octadecylamine acetate.

The obvious solution to the difficulty is the removal of the major portion of the amine, and to analyze for the impurities remaining in the residue. The following are chemical means of separation and analysis which are offered as a partial solution to the problem:

A. *Amine content*

The amine number is determined by the usual method of titrating with standard percholoric acid in glacial acetic acid (Terry *et al.*, 1952). The end point should be determined by a potentiometric method using a glass-electrode pH meter, since indicators may give shifting end points.

The manufacturer is usually able to supply an approximate average molecular weight for the amines present in the commercial products. This molecular weight, together with the amount of standard acid used, enables one to calculate approximately the weight of amine present in the sample.

Allowance must be made for the fact that usually primary, secondary and tertiary amines are all present. If necessary these can be determined by standard procedures (Wagner *et al.*, 1947).

B. *Removal of the amine*

The amines themselves are the most basic constituents which are expected to be present in commercial preparations of high molecular weight amines. This suggests that the basic properties can be used to separate the amines from the other compounds. Considerable experimentation led to a usable procedure for removal of the amine.

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MATERIALS AND METHODS

The materials necessary for the analysis are pure benzene, pure acetone, a glass-electrode pH Meter, and a standard oxalic acid solution. The latter is 1.000 molar, and is prepared by dissolving 126.1 g. of $H_2C_2O_4 \cdot 2H_2O$ in almost a liter of acetone, and diluting to a liter after the cold solution has attained room temperature. A saturated solution is about 1.5 molar.

A sample of amine or amine acetate weighing 3.00 g. is dissolved in 100 ml. of benzene. Slight warming will aid the process, and is sometimes necessary for the more insoluble materials. From the amine number, A, of the amine product a calculation is made of the theoretical amount of oxalic acid solution needed to precipitate the amines as the amine acid oxalate.

$$V = \frac{3.00\ A}{56.11}$$

This volume of oxalic acid solution, plus 1 to 2 percent excess, is added dropwise from a burette, with constant stirring. (Oxalic acid is insoluble in benzene and will precipitate if the acetone solution of oxalic acid is added to pure benzene. The slow addition and stirring are intended to disperse the oxalic acid so that it reacts with the amine.) After standing one-half hour or more to insure complete reaction, the bulky gelatinous precipitate is filtered by suction and washed with benzene. A fine-porosity fritted glass buchner funnel is quite satisfactory. A covering of a filter aid, such as "Super Cel," will prevent plugging of the pores, and make cleaning of the funnel easier. The benzene is evaporated to "dryness" by gentle warming in a casserole or evaporating dish. The residue is considered "dry" when no odor of benzene or acetic acid is detectable.

The following materials were used: purified hexadecylamine acetate; a standard sample containing 95 percent hexadecylamine acetate, 3.00 percent Arneel 18D (chiefly stearonitrile), 1.00 percent hexadecylacetamide, and 1.00 percent stearamide; Armeen 16D (chiefly hexadecylamine); Armeen 2HT (chiefly dioctadecylamine); Armac HT (chiefly octadecylamine acetate); Armac 2HT (chiefly dioctadecylamine acetate), Alamac 26D (chiefly octadecylamine acetate); and Rosinamine D (chiefly dehydroabietylamine).

The purified hexadecylamine acetate was prepared by adding 144 g. of commercial hexadecylamine to about 300 ml. of benzene, adding 36 g. of glacial acetic acid, warming to 45–50° C to dissolve all of the material, and filtering the precipitate after cooling to 20–25° C. (It should be noted that the heat of reaction of the amine and acetic acid is rather high.) The product was recrystallized twice more from about 300 ml. portions of benzene, left in the air until the odor of benzene disappeared, then dried in a desiccator over magnesium perchlorate. Four samples, titrated with standard perchloric acid, gave an average molecular weight of 299.7 with an average deviation of 0.4. The molecular weight of hexadecylamine acetate is 301.5. The low apparent molecular weight can be attributed to a slight loss of acetic acid. The melting range was 77.5–79.0° C, with a slight sintering before this temperature.

The standard hexadecylamine acetate was prepared by melting 25.65 g. of hexadecylamine acetate in a round-bottom dish, quickly dissolving 0.81 g. of Arneel 18D, 0.27 g. of N-hexadecylacetamide, and 0.27 g. of stearamide, then rapidly cooling the mixture with constant stirring and milling with a spatula until quite solid. Titration showed an apparent molecular weight of this amine-containing material to be 313.7 ± 0.5, compared to the expected value of 314.7. Again the deviation can be attributed to a slight loss of acetic acid.

The N-hexadecylacetamide was prepared by refluxing hexadecylamine with an excess of acetic anhydride in the presence of acetic acid, adding the mixture to ice, then recrystallizing the dried product three times from benzene.

The stearamide was obtained from Eastman Kodak Co.

DISCUSSION

Results for several materials are given in table 1. It can be seen that a small amount of amine may be carried through in solution in the benzene, particularly in the case of very high molecular weight straight-chain primary and secondary amines. Therefore, the procedure should be reasonably standardized so as to insure that the same amount of amine is present after the evaporation of the filtrate. This amine is determined by titrating samples of the residue with standard perchloric acid in glacial acetic acid. The amine is assumed to be present as the amine acid oxalate. It can be seen from the table that at least 97 percent of the amine is removed by one treatment with the oxalic acid.

TABLE 1

Residues from 8 g. of amine products oxalic acid-bensene procedure

Material	Wt. of Residue	Average deviation	% of amine acid oxalate in residue	No. of samples
Hexadecylamine acetate	0.005	0.002	0	4
Standard hexadecylamine acetate	0.148	0.003	0	6
Rosinamine D*	0.164	0.003	0	6
Armeen 16D+	0.072	0.02	2	2
Armeen 2HT+	0.34	0.01	27	2
Armac TD+	0.26	0.03	10	3
Armac 2HT+	0.27		24	2
Alamac 26D≠	0.26	0.03	10	4
Alamac 26D, ≠ pure sample	0.11	0.01	17	2

*Distilled sample, courtesy Hercules Powder Company
+Courtesy of Armour and Company
≠Courtesy of General Mills

If desired, the precipitate of amine acid oxalate can be dissolved by heating in glacial acetic acid, and the amine content determined by titrating with the standard perchloric acid.

The limits of the amounts of impurities which can be isolated by this method may be deduced from known solubilities. At room temperature 100 ml. of benzene will dissolve 90 g. of stearonitrile (Ralston, 1948), or 0.35 g. of Armid HT, which contains about 75 percent stearamide and 25 percent palmitamide (Armour, "Armids"). An experiment showed that, at 30° C, 100 ml. of benzene will just dissolve a mixture of 0.15 g. of N-hexadecylacetamide and 0.15 g. of stearmide. Cholesterol is soluble in benzene to the extent of 12.5 g. per 100 ml. at 20° C (Seidell, 1941). The method will thus isolate about 5 percent of amides and N-alkylacetamides. Very few commercial preparations can be expected to have this much amides or N-alkylacetamides. There is no practical limit to the amount of nitriles and sterols which can be isolated.

The efficiency of recovery of non-amine material is shown by the results for

the standard hexadecylamine acetate mixture. The sample contained 5.00 percent of impurities, and an average of 4.93 percent were isolated in the residue.

The results for the various commerical samples are not intended to be definitive, but to indicate the applicability of the method.

C. *Determination of nitriles*

Nitriles can be easily hydrogenated to amines, and the amines can be titrated quite accurately with standard perchloric acid in glacial acetic acid. It was demonstrated that nitriles can be quantitatively hydrogenated in glacial acetic acid by the use of a platinum catalyst (Adams *et al.*, 1928).

MATERIALS AND METHODS

The materials necessary for the nitrile analysis are pure acetic acid, platinum catalyst, pure hydrogen, Parr hydrogenator equipped with shaker, and standard 0.1 normal perchloric acid in glacial acetic acid. The latter is prepared as before.

TABLE 2

Nitriles in amine products

Material	%Nitrile	Av. dev.	No. of samples
Standard Hexadecylamine acetate	2.92	0.16	4
Rosinamine D	0.60	0.06	3
Alamac 26D	3.8	0.3	2
Same, purified sample	1.7	0.3	2
Armac TD	5.1	0.3	2

A sample containing 0.2 to 5 millimole of nitrile is dissolved in about 50 ml. of glacial acetic acid, 0.05 g. of the platinum catalyst added, and the material hydrogenated by shaking in an atmosphere of hydrogen for three hours at 40–50 psig. The resultant solution (with suspended catalyst) is transferred quantitatively to an appropriate flask and titrated with the standard perchloric acid. A potentiometric titration using a pH meter is preferred to the use of indicators. A blank is run on a separate sample containing the nitrile. The increase in basicity of the sample upon hydrogenation corresponds to the amount of nitrile originally present in the sample.

A sample of adiponitrile obtained from Eastman Kodak Company showed an apparent degree of completion of 99.5 percent. This is assumed to represent the purity of the sample. A commercial sample of mixed nitriles (Arneel TD, chiefly stearonitrile) showed 99 percent completion. This is within the limits of error of the purity and average molecular weight of the sample as calculated from data supplied by the manufacturer (Armour, "Arneels"). Stearamide and N-hexadecylacetamide were shown to be inert to hydrogen under these conditions. Raney nickel also may be used, but the end point in the titration is difficult to obtain.

This method was applied to the residues from the oxalic acid-benzene treatment of commerical amine products, and the previously described standard sample containing 3.00 percent nitrile. When information on the molecular weight of the nitrile was not available, its molecular weight was assumed to be four units less than the average molecular weight of the primary amine present in the original sample. The results are given in table 2.

ACKNOWLEDGMENT

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Kinships of Animals and Man. *Ann H. Morgan.* McGraw-Hill Book Co., Inc. New York. 1955. viii+839 pp.

All living things are composed of like substances, put together in the same unique way. Kinships based upon these similarities form the central theme of this book.

After laying a "Foundation" of facts about matter, energy, and familiar natural processes, and citing the cell as a sample of complete organization of living matter, the discussion proceeds to photosynthesis, the competitions and cooperations of animals, and of communities. Emphasis is placed upon the need of organisms for water, as a main constituent of internal as well as external environment. About half of the book is devoted to presentation of the orders and classes of animals, with emphasis on an evolution of forms in a sequence which forms the basis for taxonomy. The final chapters present the scheme of classification, with good consideration of applied ecology (conservation).

The treatment of each phase of this subject matter is intensive, and there are excellent illustrations (photographs and drawings) on almost every page. Teachers will find this book the product of an inspired teacher, and very useful at college level as a reference text.

THOMAS H. LANGLOIS

Man's Physical Universe. *Arthur Talbot Bawden.* The Macmillan Co., New York. Fourth Edition, 1957. xv+822 pp. $6.25.

A text for use in two semester survey courses of the physical sciences such as those being developed in general education programs.

Topics covered are from the fields of Astronomy, Geology, Physics, Aerodynamics, and Chemistry. In addition, the first unit is on the scientific method and the importance of the intelligent solution of problems to our society. The emphasis throughout is on the way the topic under consideration fits into everday experience and living. To show the relation between science and technology, in many instances well known trade name products have been used as illustrations.

The text is divided into units and sections. Each section is designed as one class assignment. The author has planned the text material around lecture demonstrations and visual aids. Upon request, the author will furnish an extensive bibliography, a list of visual aids, and a summary of the text to an instructor using this text. To whet the interest of the pupils as individuals, the author recommends reports on outside reading of current articles or books. Numerous study questions are found at the end of each section.

EDWARD S. FOSTER, JR.

CHANGES IN THE STATUS OF JAPANESE WOMEN

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Nothing in this world is static, especially cultures. Arnold W. Green (1956) writes, "Culture and the social institutions which transmit culture to succeeding generations are themselves conservative forces. Nevertheless, the moral norms and social values, the culture and social institutions, of any society, all change through time." Thus, the statuses of women in various cultures change, due to factors both internal and external, and those of Japanese women present one of the most dramatic pictures of such changes.

Japanese society was deeply steeped in feudal culture until 1854 when Commodore Perry pried open the Japanese trading gate to the sharply contrasting, industrialized Western cultures without any shock-breaking intermediary period. In the case of western European and American (U.S.) cultures, the Renaissance, the individualistic doctrines of Protestantism, Romanticism, the political rationalization of the Enlightened period and, especially in the case of America, the economic frontier conditions helped to smooth out the straining transitional period from the feudal culture to the industrial and urban culture. Japan did not have all these benefits. She was forced by circumstances to catch up with Western culture, technologically and intellectually, in less than one hundred years, a transition which the West made in several centuries. This traumatic social change was due to the rapid industrialization and modernization under Western influence; it did not leave any aspect of Japanese culture unaffected. The status of Japanese women was affected directly and indirectly, and changed consciously and unconsciously during the westernization processes. The notable changes in the women's status since 1854 shall be presented.

In the dawn of Japanese history, approximately 2000 years ago, women seemed to have had esteemed positions. The "god" who started the "unbroken and divine" emperor line and whose grandson became the first emperor of Japan was a woman, according to a Japanese myth. There is no lack of incidences of ruling empresses in Japanese history. According to one source, one empress appeared before the time of the Norman conquest and the last one around the time of the American Revolution. A great amount of literary works was produced by women's pens. However, since the Confucian teachings and ethics were introduced by Achiki and Wani around the 3rd century AD, women began to be subordinated to men. Confucius says that women must obey their fathers when little, their husbands when married, and their elder sons when old. Women's status was a life-long submission to men. The neo-Confuciansim of the 12th and 13th centuries further strengthened this position.

As the feudal system had developed during the Kamakura period (1192–1339) and became stable under Tokugawa period (1600–1868), the throwing off of the yoke of subordinate status became more hopeless. Though the Tokugawa adhered to the Confucian teachings, the Confucians' cardinal principle of relationship—that of father-son—was distorted and one's loyalty to the feudal lord became the first concern. All privileges, power and fame were concentrated in the Samurai or the warrior. Honors were definitely associated with being Samurai and Samurai became the ideal of men. In the social organization which stressed and upheld the status of warrior, women tended to be mere servants for the needs of men. The feudal society, rooted in Confucian learning and Buddhism, regarded women as a source of necessary evil and only as a means for perpetuating the family line and name, and designated the most honorable place of women in the home as submissive wife and mother to the warrior. The double moral standard merci-

lessly punished women's adultery but let men have free sex adventures. Women could be divorced for just being jealous of a husband's sex excursions. The traditional saying that "It is shameful to be jealous," kept them calm and smiling.

After 1854, under the enlightened Emperor Meiji (1868 1911), the hasty modernization of the newly consolidated country was launched. The compulsory public education system was decreed by a Rescript of 1871 and the constitutional monarchy was adapted after the British model. A modern banking system was set up and large government subsidies helped to build the industries and commerce. The national transportation and communication were under government management. Power plants were installed by the government. While the technical transplanting was pursued with great eagerness and ease, the attitudinal aspect of culture lagged behind.

Laws governing interpersonal relationships and the rights of women in particular reflected the traditional treatment of women. In spite of the feminists' cry for emancipation of women (influenced by Rousseau's "natural rights of men"), Article 5 of the Peace Preservation Law prohibited women's attending political meetings or participating in political activities. Women could own property but control was in the hands of husbands. A widow could not inherit her husband's property. Adultery by women was punishable but by men was not. As a matter of fact the court ruled that men could keep concubines as long as they were discreet enough to keep them secret. The marriage laws were such that women were in precarious positions as to the loss of legitimacy of their marriages and even of their children.

During the 1920's, the women's movement for the betterment of women's lot reaped handsome results. This is only one of the evidences of the liberal and democratic trends of the time. After World War I, Japan enjoyed a tremendous economic prosperity. She actually profited from the war by selling war goods to the Allies and capturing the markets for cotton and silk goods in the Far East while the British were busy winning the war. Along with this economic prosperity, the democratic ideologies and liberal thinking became the vogue after the Wilsonian Democracy. It was during this period that labor parties, farmer parties, and labor unions began to gain strength. The political parties, such as the Social Mass Party, the Labor-Farmer Party, and the Workers' and Peasants' Party, cooperated with the Federation of Women Association which was established in 1923, in emancipating women politically and socially. It was during these liberal 1920's that Article 5 of the Peace Preservation Law was modified to give women the right to hold their own political meetings in 1922. When the League for Realization of Women's Suffrage was organized in 1924, the Women's Associations gained the support of the proletarian parties. They began to push the movement for women's suffrage, after seeing universal suffrage (men's) enacted in 1925.

Prior to the 1920's, women were badly exploited economically. There was wage discrimination against women teachers. The textile factory girls were virtual slaves to the factory owners who had contracts with the parents of these girls. Under the government policy of rapid industrialization, the farmers were ruinously taxed and were forced to send their teenage girls to town to earn some cash for tax money. The wages were too low; the working day was around 11 hours; the working conditions were dangerous to health and the dormitories factory owners provided were pitiful. It was not uncommon for women to work in the mines and there were no provisions for expectant mothers. No labor union for women workers was permitted, but a women's department of the men's All-Japan General Federation of Labor was organized in 1917 and served the supposed function for them. Occupational opportunities were limited. There were almost no women government officials appointed by the Emperor. There were no chairs for women in the government universities. The bar prevented women from becoming lawyers, until 1938 when for the first time a woman passed the examination.

And by 1938 there were only 14 women doctors of medicine, 4 women doctors of science, and 2 women doctors of agriculture. The 1920's again brought some correction of unfair economic treatments of women. In 1929, the Washington Labor Agreement motivated the government to pass a law to prevent night shifts for girls. The factory law of 1911 was revised in 1929 to give better protection, prenatal and postnatal, for expectant mothers. The International Labor Conference was instrumental in moving the Japanese government to forbid the entry of women into the mines. However, women still were not able to organize their own labor unions for economic benefits.

As in the 1930's the conservative militarists and landowners collaborated to gain political power, obliterating the liberal, democratic trends of the 1920's, the feminists' movement encountered more obstacles. The suffrage and civil rights bills were constantly defeated at the Imperial Diet sessions. Women's labor unions were out of the question. Even a Home Affairs Ministry sponsored-bill for abolishing prostitution was defeated in 1937. So frustrated, the feminists changed their tactics and began to muckrake the municipal administration level. The result was the exposure of the corruption in city government, especially in Tokyo.

At the same time the women's movement directed its effort to the protection of motherhood. As foreseen, there was little government opposition to this campaign. Under the ultra patriotic, militaristic government, there was a wide propaganda appeal for strong healthy children, preferably boys for the service of Emperor and country. By this time the militarists in power had launched the imperialistic expansion in Manchuria and China and needed strong mothers to produce strong, brave soldiers for their dream of world conquest. Tetsu Katayama (1938) says, "It seems that they are well advised to limit their activities to 'saving the poor mothers and protecting the poor children,' if they are to carry on any movement at all; for this is the time when, due to the tide of nationalism and the introduction of a semi-wartime system, not only has the question of women suffrage been completely submerged, but even parliamentary government itself is inevitably being impeded, though temporarily, in its unrestrained function." Meanwhile the League for the Protection of Motherhood under Waka Yamada was organized and finally in 1937 a Protection Law was passed by both houses of the Diet to support needy mothers and children. Even in the efforts for the protection of women workers, the main object was not to better the lot of working women per se, but to give adequate protection to mothers for the children's sake. This unproportional amount of attention given to motherhood is definitely in line with the dominant government policy of the expansionalists and with the traditional view of women as a means for the perpetuation of the family line.

During the Japanese involvement in World War II, motherhood was further exalted. Mothers with many sons were rewarded and pictured in the newspapers. And as the shortage of man power was felt in the desperate days of the War, women were encouraged to plow the fields, to operate the machines in factories, and to fill in the vacant jobs left by men. Now women became the *yamato nadesiko*, meaning "the daughters of country," and as valuable as men for the war effort. Probably the increased economic opportunities and actual testing of the women's ability to carry out men's work helped to boost women's confidence in themselves and helped them to adjust easily to the democratic ideology of American military government after the War.

The American military government landed in the Japanese islands with the best intentions to reform the "belligerant delinquent" into a more peace-loving democratic country. The task required the remodeling of the old autocratic social system into the democratic one of American type. The occupation initiated the coeducational system in the secondary schools and colleges. Changes in the curriculum for the girls' secondary schools were introduced to insure that girls would get the same professional training as boys, for in the past girls in the

secondary school were trained only to become good homemakers. In 1946 women also were admitted for the first time into the Imperial University, and the length of compulsory education was expanded from 6 years to 9 years in 1947. Women were given suffrage and thirty-nine women were elected to the House of Representatives in 1946. New job opportunities opened. Women are now elected and hold government offices. Policewomen appeared on the scene. And even a mine strike was called by a woman union leader. Finally, prostitution was abolished in 1956; women are allowed to initiate separation proceedings against husbands and to get court-granted alimony under the new Civil Law; and women can inherit property. On the surface it seems that Japanese women are making great progress toward equal status with men, but more close examination reveals a less optimistic picture.

An attractive girl in fashionable Western dress walking arm in arm with her G.I. boy friend gives the misleading impression that Japanese women have finally reached the goal of domestic freedom. This girl represents only a minority. The women in rural areas and fishing villages have changed little in their attitude toward themselves and men. Being busy in the fields and on the beach all day long, these women do not have the leisure to be subject to all the new democratic propaganda and to think about their civil rights.

Some begin to doubt the advisability of the changes in the curriculum for the girls' secondary schools. After all, most of the girls end up in marriage and all the professional education is not so useful for homemaking. More often than not, women tend to vote as husbands bid them. There is still salary discrimination against women teachers and actually there is a trend to hire men more often than women. The return of men from overseas and the economic confusions of the postwar period created an acute shortage of employment. Recently, it was noted that about 65 percent of college graduates could find any employment. As yet there is no separate women's labor union organized. It is true that now women can inherit property from husbands but as the eldest son is born the property becomes his. It is still frequently practiced that parents make contracts with factory owners or the owners of tea houses for their daughters to work for a certain number of years. It is a fact that there is an increase in women's occupational opportunities but not enough to satisfy all the newly acquired needs for luxuries and freedom.

Some people think that, after Japan resumed governing its own affairs in 1952, there was a trend toward the old conservatism. Once awed by the democratic ideologies and General MacArthur, people began to pause before they followed blindly the American models. There was great relaxing of women's time-honored chastity after the War and American romantic love and freer divorce proceedings increased the divorce rates. It is easy for girls to appear in stylishly tailored dresses and to drive a car, but the age-old traditions, entrenched firmly in every nook of the culture, will not change overnight.

It should be pointed out that there is a tendency to over emphasize the effects of the American military government policies on the Japanese women's status. Actually, the change in the women's status away from the subordination toward the equalitarian status had started even before the two World Wars. The process was a slow and strenuous one and probably the democratic policies of American military government really accelerated the already existing trend toward the equal treatment of women in Japan. However, it would be safe to be a little conservative in estimating the postwar effects on the women's status.

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MAJOR GLACIAL DRAINAGE CHANGES IN OHIO[1]

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During the Pleistocene epoch, glaciers, probably several thousand feet thick, advanced at least four times over much of the northern part of the United States. These are usually referred to as the Nebraskan, Kansan, Illinoian and Wisconsin glaciations. It has been estimated that the Nebraskan, or first advance, was probably one million years ago and that thousands of years intervened between each advance. There is positive evidence that the Illinoin and Wisconsin glaciations spread southward until all of the northern and western parts of Ohio were covered by the ice. Evidence that the Nebraskan and Kansan glaciations invaded northern Ohio, although indirect, has been accepted as sufficient by many geologists.

The advance of the glaciers into Ohio seems to have brought about as great, or greater, drainage changes in Ohio than in any other part of the United States. The most important changes were due to the earlier ones. This paper will, therefore, give most consideration to those changes, which the evidence indicates, were the result of these earlier glaciations, particularly those in the present Scioto and Miami valleys.

Perhaps not enough emphasis has been given to the changes that may have taken place during the advance of the same glacier, which Goldthwait estimates "at fastest known speed took 5,000 years to cross the state the first time," nor to the different changes which resulted from the advance of *each* of the earlier glaciations and during the thousands of years that intervened between them. While the evidence of such changes may not be conclusive, it seems sufficient to justify giving it careful consideration.

Perhaps, the most important factors in determining the changes are the elevation and slope of the present surface, and also of the rock surface where available, and the location of the main divides, valleys and streams. The advance of the different glaciations brought about so many reversals and other changes in the streams and the formation of new channels, or the deepening of the old ones, that it is often difficult, or even impossible, to determine the exact location of the preglacial divides and streams. There is some positive evidence that in preglacial time the drainage of all streams in Ohio, including those in the present Scioto and Miami valleys, discharged northward into the present Lake Erie Basin.

Preglacial Divides and Drainage

Based upon the best evidence obtainable, Ohio has been divided into four main preglacial drainage basins: the Northeastern, the North-Central, the Central-Southeastern and the Western Basins. A map of these Drainage Basins, with the principal divides and preglacial streams, is shown as figure 1. This should be compared with the Teays Stage Drainage map by Stout, Ver Steeg and Lamb (1943), shown on page 50 of a report on the Geology of Water in Ohio, which also has several other maps of the drainage systems resulting from the different glaciations, and on page 48 on a "Relief on Rock Surface" map by Stout, which has very much helpful information.

[1]Paper read before the Geological section of The Ohio Academy of Science at Bowling Green, Ohio, April 19, 1957.

Northeastern Drainage Basin

The Northeastern Drainage Basin lies east of the divide, extending from the preglacial divide across the present Ohio River Valley in Monroe County northward by Barnesville, Cadiz and Ravenna to Geauga County and Lake Erie. The drainage included that of the present Ohio River Valley north from the old divide to Beaver Falls, Pennsylvania, where it joined the Pittsburgh drainage, flowed

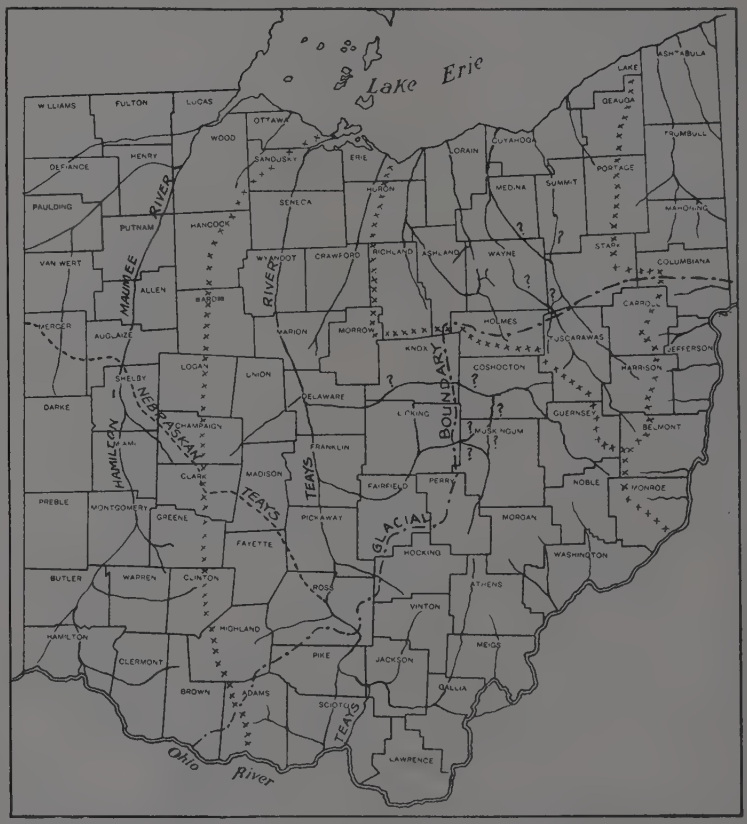

FIGURE 1. Major preglacial drainage basins, divides and streams. The location, especially of the streams, is necessarily approximate, and where particularly so, is indicated by a question mark ?. Divides are indicated by xxxx and streams by — — —. The glacial boundary is also shown by-·-·- and the interglacial Nebraskan-Teays River by - - - - .

northward through the present Mahoning and Grand River valleys to the Lake Erie Basin. The elevation in most of these two valleys is less than 1,000 feet and the surface is more like the Plains than the Plateau.

The North Central Drainage Basin

The North-Central Drainage Basin is situated west of the divide just described and north and east of the divide, which extends northwest from Belmont County

across the present Tuscarawas River Valley near Port Washington and on into Holmes County, thence west to Morrow County, where it turned North through the Plains to the Lake Erie Basin, probably in Erie County.

The drainage changes in this Basin are probably more complicated than in any other part of Ohio. In the November, 1930, issue of The Ohio Journal of Science is an article by the writer with a map on which is indicated the possible preglacial, interglacial and postglacial drainage in most of this Basin. The evidence seems to indicate that in preglacial time there was a number of streams, including the present Stillwater, Conotton, Killbuck, Jerome and Black Fork creeks, as well as the Cuyahoga and Chagrin rivers, which flowed northward into the Lake Erie Basin. At that time the streams in the Plateau, except perhaps near the escarpment, had not cut out deep valleys, the elevation of the valley floors probably being more than 1,000 or even 1,100 feet above sea level.

Central-Southeastern Drainage Basin

The Central-Southeastern Drainage Basin is bounded on the east and Northeast by the divide, extending from Monroe County northwest and west to Morrow County, and then north to Erie County on the lake; on the southeast and south approximately by the present Ohio River; and on the west by a line running north from the present Ohio River in Adams County along the divide between the present Scioto and Miami valleys to Hardin County, and then probably northeast to the Lake Erie Basin west of Sandusky Bay. The southeastern and southern parts are a part of the Plateau, of which very little if any was covered by the earlier glaciations, but the later ones, especially the Illinoian, advanced onto the western portion particularly from Fairfield County northward to Richland County.

In preglacial time the elevation of the northern portion of the Plateau in this basin was probably more than 1,000 feet above sea level and some of it as much as 1,200 to 1,400 feet, but in the southern portion is now less than 1,000 feet and much is below 800 feet. An outlier of the Plateau along the western border of this basin in Logan and Champaign counties includes east of Bellefountaine the highest elevation in Ohio, which is 1,533 feet.

In the Plains section the elevation of the rock surface, as shown on page 48 of "Relief on Rock Surface" map by Stout already referred to, rises gently from less than 600 feet along Lake Erie southward to the upper Scioto Valley, where, for a width of 30 miles or more it is less than 1,000 feet and much of the upper and lower portions are less than 900 feet, while that of the divide, along its western border from the outlier of the Plateau in Logan County south almost to the Ohio River, is more than 1,000 feet, except in the narrow abandoned valley where the Nebraskan-Teays River broke over and in Champaign County cut a channel through an area where the rock surface on each side is more than 1,100 feet. The width of this broad valley, which extends northward from Columbus between two of the highest points in Ohio, and the lower elevation of the rock surface in this valley, as compared with that of the divide along its western border, furnish positive evidence 1) that the preglacial Teays River flowed northward from Chillicothe and was primarily responsible for the formation of this broad valley and 2) that the abandoned channel northwestward from Chillicothe to Indiana must have resulted from the later blocking of this northward flow of the old Teays River by the advance of the Nebraskan glaciation, causing it to break over the divide on the west and, during the thousands of years before the coming of the Kansan glaciation, to cut out this deep, narrow valley, making it interglacial rather than preglacial in origin. This offers a logical explanation of the origin of this broad upper Scioto Valley which it is difficult to explain satisfactorily otherwise.

Western Drainage Basin

The Western Drainage Basin includes all of Ohio west of the divide just described and now occupied principally by the Maumee and Miami valleys. The

rock surface rises gradually from less than 600 feet along Lake Erie, and much of the Northern portion of the Maumee Valley, to more than 900 or 1,000 feet in the Miami Valley, except in the middle and southern portions, where it gradually lowers to less than 800 or even 700 feet.

Most geologists agree that the preglacial drainage in the Maumee Valley was northeastward into the Lake Erie Basin and that the drainage of the central part, which includes the present divide between the Maumee and Miami valleys, was northwestward by means of the Teays River into Indiana, as indicted on the Teays drainage map already referred to. However, they do not agree as to the preglacial drainage in the southern part. Some think it was southwestward into what is now the Ohio River Valley while others believe it was northward and joined the Teays River.

On page 53 of a recent publication Wayne (1956) states, "I believe that preglacial Hamilton River probably flowed northeastward"; and on page 35 he states, "the data used to prepare the maps showing drift thickness and bedrock topography of northeastern Indiana indicate the slope of the bedrock surface must be eastward toward Ohio and the Lake Erie basin rather than to the southwest," which apparently agrees with the slope on "Relief on Rock Surface" map of Ohio already referred to. This and other evidence lead to the conclusion that all of the preglacial drainage in the Western Drainage Basin was north and eastward into the Lake Erie Basin, that the Teays River across the central portion was formed during the Nebraskan glaciation, and that the lower elevation in the present Miami Valley has taken place since the advance of the Kansan glaciation. It does not seem logical that a large stream like the old Teays River would have naturally developed on a divide like that between Lake Erie and the Ohio River.

Nebraskan Glaciation

Evidence strongly indicates that the first advance of the ice into Ohio was the Nebraskan glaciation. The advance was from the northeast along the Lake Erie Basin, from where it spread southward, the tendency being to flow around the higher parts of the country and spread out like a fan from the lower valleys. The ice blocked the northeastern preglacial drainage of the old Lake Erie Basin and formed a lake, the level of which continued to rise until it overflowed westward into Indiana. All of the Ohio drainage would then have been into this glacial lake until the southern border of the ice successively blocked the northward flow of the streams and forced many of them to seek new lines of discharge, probably at first across the divides between them and later resulting in the reversal of many streams and cutting out of new, or the deepening of old, channels southward. As the glacier came from the northeast it may have taken a thousand or more years for it to move westward to the Indiana line.

When the glacier advanced far enough south to encounter the northern boundary of the divide, forming the western boundary of the northeastern Drainage Basin, it blocked the old Pittsburgh drainage and formed a lake, which rose until it reached the lowest elevation in the divide along its western border, apparently south of Ravenna, as previously suggested (Coffey, 1914, 1930). As the Grand River glacial lobe advanced south of Ravenna, as it apparently did, the lake continued to rise until it broke over the divide in Monroe County and joined the old Marietta River which united with the Teays River in Jackson County.

As the glacier moved westward around the highlands in Geauga County it successively blocked the streams in the North-Central Drainage Basin, resulting in such a complexity of changes in the drainage as to make it impossible to determine definitely the preglacial, or post Nebraskan, location of the streams. The Pittsburgh drainage, which apparently broke over the divide near Ravenna, may have flowed northwestward for many years along the old valley described by

Scranton and Lamb (1932) as extending from southeast of Alliance northwestward across the divide near Ravenna.

The blocking of the drainage in the old Cuyahoga Valley resulted in the formation of a lake. It rose and probably found successive temporary outlets northwestward along the present Chippewa and other valleys leading northwestward from it until the ice moved far enough south to block these outlets and to cause the lake to break over the divides near Justus and Port Washington and form a stream, which flowed southwestward and joined the Nebraskan-Teays River in Madison County. This might help to explain the complexity of the deep valleys now occupied by Chippewa Creek and other streams in this section. They are shown in detail on map by Ver Steeg (1934).

In the Plains section the Nebraskan glacier extended far enough south to block the northward flow of the old Teays River and also that of the old Hamilton-Maumee River. The blocking of the Teays drainage resulted in the formation of a lake in the present Scioto Valley. The lake continued to rise until it broke over the western divide in Clark County, joined the old Hamilton drainage, and continued on northwestward into Indiana, thus forming a new or Nebraskan-Teays River from the old Teays at Chillicothe. As this Nebraskan-Teays River included not only all of the Ohio drainage but also the West Virginia and Kentucky and the Pittsburgh drainage; it must have been a large stream. During the thousands of years that intervened before the coming of the Kansan glaciation, the stream cut out the deep valley extending from Chillicothe northwestward across the divide into Indiana.

After the retreat of the Nebraskan glaciation, the drainage in the northern part of the state again discharged into the Lake Erie Basin. The upper Tuscarawas drainage, which had broken over the divide near Port Washington, apparently reversed its course and discharged northward along the old Tuscarawas and Cuyahoga valleys and contributed to the rapid lowering of the stream channels in these valleys, where, according to White (1953), "well records in Cuyahoga River valley indicate the valley floor to be 100 feet or more below sea level near Gordon Park at the lake shore."

The Pittsburgh, Hamilton, and Teays drainage remained very much the same until the coming of the Kansan glaciation. The much shorter distance from the Flusing escarpment in eastern Ohio to the Lake basin, as compared with that from east of this escarpment along the old Pittsburgh and Teays drainage to Indiana, may offer at least a partial explanation of the apparently more rapid and deeper erosion, which resulted in the differences in the physiographic features east and west of this escarpment.

Kansan Glaciation

The Kansan glaciation apparently advanced farther south than the Nebraskan, especially in the Plains section, and blocked all northward drainage into the Lake Erie basin and also that of the Nebraskan-Teays and Hamilton drainage northwestward into Indiana. The Hamilton drainage was reversed and as the ice advanced farther south the Teays River apparently broke over its southwestern bank in Clark County and joined the reversed Hamilton River at Dayton and continued southwestward to become eventually a part of the Ohio River west of Cincinnati. Further advance of the ice forced the Teays River drainage to flow southward to Portsmouth, where it turned westward, broke over the divide in Adams County, and continued to near Cincinnati. From here it followed the old Licking River northward and joined the reversed Hamilton River. Together they flowed southwestward and broke over the divide near Madison, Indiana, thus forming the present Ohio River, except the section south of Cincinnati, which probably was formed at the later advance of the Illinoian glaciation.

The long interglacial period before the coming of the Illinoian glaciation would

have resulted in degrading the surface, thereby forming the present broad Scioto and Miami valleys, as well as lowering the surface in other valleys in the state. Perhaps "Deep Stage" drainage really consisted of two stages, Nebraskan and Kansan.

While the evidence indicates that the Kansan glaciation extended farther south in western Ohio than the Nebraskan, it is not possible in the northeastern part of the state to determine definitely to which glaciation certain changes were due. However, the Kansan glaciation doubtless produced some changes in the drainage as well as in the deepening of many stream channels.

Illinoian and Wisconsin Glaciations

The Illinoian and Wisconsin glaciations advanced much farther south than the earlier ones and produced important changes in the drainage but there are differences of opinion as to when some of these changes took place.

It is generally agreed that the Illinoian glaciation advanced across the Ohio River at Cincinnati and east as far as Brown County. The border then extended northeastward to Muskingum County and then north to Ashland County. From there a map in Bulletin 44 by Stout, Ver Steeg, and Lamb (1943) extends it northward to the Lake in Erie County. They believe that the ice barrier on the Ohio River at Ripley completely obstructed the drainage to the west, resulting in the reversal of the Ohio River and the discharge of all the drainage east of the ice border northward into the Lake Erie Basin. White (1951), however, is positive that the "fringe" east from Canton to Pennsylvania is of Illinoin age.

In discussing the glaciation south of the Ohio River Wright (1890) states, "the amount of drift transported is trivial. The fact, therefore, that the ice bridged the chasm of the Ohio does not necessarily carry with it the view that it blocked that chasm to the exclusion of the river." The rather large streams that flow under some of the present glaciers, the ice of which is several times harder than normal ice, as well as other evidence, support Wright's statement.

As the Illinoian glaciation advanced southward it blocked the streams flowing west-ward into the present Scioto Valley. This resulted in their breaking over the divide on the east and in the formation of the present Muskingum and Hocking rivers. There were probably also changes in the Walhonding and Mohican rivers although the latter is east of the Illinoian border and may have been due to the Wisconsin glaciation, as the eastern border of the Illinoian glaciation on map by White (1934) is west of the present stream and the post-Illinoian drainage may have continued east along the broad valley to the Killbuck near Shreve, until the coming of the Wisconsin glaciation.

As the Wisconsin glaciation did not extend as far south as the Illinoian, except from Ashland County east to Canton, it apparently did not cause important changes in the drainage, except in the northern Plains, where the location of the present streams was much influenced by the moraines. Another example is in the Tuscarawas Valley, where it blocked Conotton Creek, causing it to break over the high divide on the west and to cut out a narrow channel through which the Tuscarawas River now flows to the broad valley at Dover.

Many other less important drainage changes could be cited. It is hoped the suggestions in this paper may prove of some assistance in solving the many puzzling drainage changes in Ohio that resulted from the different advances of the ice.

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Economic Geography of Ohio. *Alfred J. Wright.* Ohio Div. of Geol. Survey Bull. 50. Orton Hall, The Ohio State University, Columbus 10, Ohio. Second Edition 1957. xviii + 245 pp. $2.06.

This second edition of Economic Geography of Ohio is a revision of Dr. Wright's geography of 1953; many photographs have been added and the tables have been brought up-to-date. The introductory chapter gives the history and the geologic background for the present geography of the state. The next four chapters discuss agriculture, mineral industries, manufacturing, and commerce. Subsequent chapters treat the various sections of the state.

Dr. Wright's experience as Professor of Geography at The Ohio State University fits him to write a readable book and a useful text on the geography of Ohio. Any resident of the state will find this book interesting reading especially as he discovers paragraphs and chapters on the city or industry with which he is most familiar and sees photographs of towns, factories, and rural scenes which he knows. Geography students will benefit from the many tables and maps which present facts in an easy-to-remember form.

This book will serve as a reference book, a text book, or just interesting reading material on the geography of Ohio.

RALPH J. BERNHAGEN

The Physiology of Fishes. Vol. I. Metabolism. ix + 447 pp. $12.00. **Vol. II. Behavior.** xi + 526 pp. $14.00. *Margaret E. Brown*, Editor. Academic Press, Inc., N. Y. 1957.

The statement by Dr. Brown (editor and contributor) establishes the common objective of the contributing authors to present "authoritative reviews of the present state of knowledge of various aspects of fish physiology" and to indicate "gaps in knowledge and possible fruitful lines for further research." The editor showed excellent judgement in her selection of authors, each of whom is eminently qualified to present his special phase of the subject. International character is given these books by the nationalities of the authors, eight from the United States, ten from England, four from Canada, one from Scotland and one from Holland.

Unfortunately the comprehensive treatment could not be condensed into one volume, but the two books could have been labelled "Volume one" and "Volume two," without the misleading titles of Metabolism and Behavior. Included in Volume one are chapters on respiration, the cardio-vascular system, the alimentary canal and digestion, excretion and osmoregulation, the skin and scales, the endocrine organs, the gonads and reproduction, early development and hatching, experimental studies on growth, and the biochemical composition of fish. Volume two consists of chapters on the nervous system, the sense organs, behavior, the swin bladder, electric organs, luminous organs, pigments, color changes, water quality requirements and effects of toixc substances, and the physiological genetics of fish.

This two volume book should have value for comparative physiologists and fisheries research workers, and it might well appeal to general zoologists.

THOMAS H. LANGLOIS

ADDITIONAL NOTES ON THE DRAGONFLIES OF NORTHWESTERN OHIO

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INTRODUCTION

These notes are based on 2400 specimens of Odonata collected by the writer and others during the eight years 1949 to 1956, inclusive. Most of the specimens were collected by the writer and are in the writer's collection, but some rarities have been donated to The Ohio State Museum and to the private collections of Dr. D. J. Borror, Dr. Philip P. Calvert and Dr. E. M. Walker. Dr. Borror has kindly checked or determined nearly all of the less common species, such as *Aeshna canadensis*, *A. interrupta*, *A. verticalis*, *Sympetrum costiferum*, and *S. internum*. The writer is further indebted to Dr. Borror for suggestions in the preparation of this paper. The records cover Auglaize, Defiance, Fulton, Henry, Lucas, Mercer, Paulding, Putnam, Van Wert, Williams, and Wood counties.

A previous paper (Price, 1950) brought the list of Odonata recorded from Ohio to 138 species; Kormondy's paper (1956) increased the number to 139 species. Five additional species are recorded in this paper, *Enallagma cyathigerum*, *Aeshna canadensis*, *A. interrupta*, *Sympetrum costiferum*, and *S. internum*, bringing the list to 144. Dr. Montgomery's paper (1943) and mine (1950) recorded 74 species for Williams County; sight records for five additional species were mentioned but not counted. These species have been secured since then, plus 21 other species, bringing the total for the county up to 100. All but two of the 100 species have been taken in two townships, Northwest and St. Joseph. Since Kellicott (1899) recorded fewer species for the entire state, it can be surmised that Williams County is a fine place for Odonata. Special attention was given to collecting in the county, as the statement was made in my previous paper: "It seems very likely that with additional collecting, Williams County, the extreme northwestern county in Ohio, will equal or exceed every other county in the state in the number of species of Odonata; it is conceivable that as many as 100 species may eventually be taken there." The Williams County list now ranks first in the state but is still far from complete; no specimens have been taken in several townships. *Anax longipes* has been seen at Mud Lake, but it is too rare and wary to consider its capture certain. The following species are certain to be added to the county list in a matter of time: *Gomphus vastus*, *Dromogomphus spinosus*, *Sympetrum ambiguum*, and *Neotetrum corruptum*.

A total of 81 species have been recorded for Paulding County; many counties will exceed it in number of species as it lacks bogs and lakes.

The localities at which the collections recorded in this paper were made are as follows:

Auglaize Co.—The State Fish Hatchery near St. Mary's.

Defiance Co.—Little (Krill's) Lake, Lehman's (Big) Lake, Ladd's Lake, a buttonbush swamp southwest of Ladd's Lake, the Auglaize River and its lagoons south of Defiance, the Miami Extension Canal, and temporary ponds in fields near Ladd's Lake.

Fulton Co.—Harrison Lake and Mill Creek.

Henry Co.—Maumee River, Miami and Erie Canal, and a large pond near the Clevite Corporation.

Lucas Co. Ponds and streams in the Oak Openings State Park, and the Maumee River near the Providence Dam.

Mercer Co. Aehbach's Landing and the Grand Reservoir (St. Mary's Lake), fish ponds just west of the Lake, and the Wabash River in Recovery Township.

Paulding Co. Maumee, Auglaize, and Little Auglaize Rivers, Flatrock, Blue and Marie DeLarme Creeks, four artificial ponds at the Great Lakes Sugar Company at Paulding, a pond

beside the Auglaize Quarries in Auglaize Township, a small pond in the woods along the Miami Canal about one half mile southwest of Charloe, an artificial pond two miles north of Melrose, the large tile pond at Haviland, various ditches along roads and between fields, various gravel pits, two abandoned quarries east of Grover Hill, and the Miami and Wabash Canals.

Putnam Co.—An old tile pond at Miller City.

Van Wert Co.—An abandoned stone quarry at Willshire, a small deep pond at the Schumm sawmill, and a tile pond northwest of Convoy.

Williams Co.—St. Joseph's River, Fish and Nettle Creeks, Mud, Nettle and Hayes Lakes, various ponds, marshes, gravel and marl pits, Dehn's Swamp in Florence Township, and several streamlets.

Hayes Lake is about one mile east of Nettle Lake; it is rectangular and has an area of about five acres. Several years ago there was a landslip on the south shore, and approximately half an acre of shore slipped into the lake; the tops of trees can still be seen under the surface. It appears to be a deep lake; the owner informs me it is 30 feet deep near the south shore. The collecting has been disappointing thus far at Hayes but has been good at a permanent pond west of the lake as well as at a permanent pond about 2½ miles east of the lake.

Wood Co.—Beaver Creek and the Portage River.

The records are given by counties; an asterisk preceding a county name indicates a new county record. The numbers are those of Borror's (1937) list.

LIST OF SPECIES

2. *Progomphus obscurus* (Rambur). **Williams**. This species occurs regularly at Fish Creek, about one mile north of Edgerton. One male was taken June 16, 1951, and 4 males June 18, 1952.

3. *Hagenius brevistylus* Selys. **Williams**. A single specimen ot this large species was seen along the St. Joseph's River in August, 1952, but it was not secured. One male was taken in the woods near Hayes Lake, June 11, 1953. It seems to be rare here.

5. *Erpetogomphus designatus* Hagen. ***Paulding***. A male was captured July 29, 1954, on a boulder in the Maumee River about ½ mile upstream from the Forder bridge; another was seen; both were very wary.

7. *Gomphus* (*Stylurus*) *amnicola* Walsh. **Williams**. This rare species has been taken sparingly. One male was captured August 25, 1949, along the St. Joseph's River north of Edgerton; another male was taken on a cool rainy day, June 20, 1951, near Fish Creek north of Edgerton. A female was secured June 18, 1952, along the St. Joseph's River southeast of Blakeslee. A male was taken August 27, 1956, at the St. Joseph's River north of Edgerton.

9. *Gomphus exilis* Selys. **Williams**. This species has a rather short season in June. It is common in the vicinity of Nettle Lake, as well as at some spots along Nettle Creek.

138. *Gomphus externus* Hagen. **Paulding**. This very wary insect occurs regularly at the ripples of the Maumee River above the Forder bridge. It seems to prefer boulders in the middle of the river and is seldom seen along the shore; when fresh it appears lighter in color than *G. fraternus* and is considerably larger. Captures were made as follows: 1 female August 13, 1949, 1 male July 16, 1952, 6 males July 19, 1953, one female August 1, 1953, and 3 males July 29, 1954.

10. *Gomphus fraternus* (Say). **Paulding, Williams**. *G. fraternus* seems to prefer creeks and rivers; I have never taken it at a gravel pit. It is the most common of the Gomphines in this area.

11. *Gomphus furcifer* Hagen. ***Williams.*** One male was collected on a water lily pad at Mud Lake June 19, 1949.

12. *Gomphus graslinellus* Walsh. ***Lucas, Paulding, Williams.*** This *Gomphus* is exceeded in numbers here only by *G. fraternus*. It occurs at creeks, rivers, ponds, lakes, and gravel and marl pits. Two males and 2 females were taken at the Oak Openings in Swanton Township, Lucas County, June 8, 1950.

14. *Gomphus lividus* Selys. ***Lucas, Williams***. On June 23, 1952, 2 males and 4 females were secured near Gale Run at the Oak Openings in Lucas County. This species is partial to spring-fed streams.

16. *Gomphus* (*Stylurus*) *plagiatus* Selys. **Paulding.** This species is fairly common at the ripples of the Maumee River above the Forder bridge, but its flight is so erratic that it is difficult to take. It spends much of its time well up in the foliage of trees and must be captured in flight; it is unusual for this species to alight on the ground or on boulders in streams. One male was taken at the above mentioned ripples August 13, 1949; several were seen on the following day but only one male was secured during three hours of collecting. Four males were taken September 2, 1955.

17. *Gomphus quadricolor* Walsh. **Williams.** This species is rare and local, and has a very short flight season. It occurs some years at Fish Creek, about one mile north of Edgerton. In 1949, 1 male and one female were taken May 23, and one female May 28.

18. *Gomphus spicatus* Hagen. **Williams.** This is an abundant species at Mud Lake, where it occurs every year. I take it sparingly nearly everywhere else. Specimens taken in late May are generally tenerals; by July 4, the species has practically disappeared.

19. *Gomphus* (*Stylurus*) *spiniceps* (Walsh). **Williams.** I enjoy collecting this species more than any other. Nearly all of my specimens have been taken at the junction of Fish Creek and the St. Joseph's River northeast of Edgerton. A few have been swept from the foliage of trees overhanging the river but most of them have been taken with a quick down-stroke, using a large net with a four foot handle as they flew past me. On a large river such as the Maumee this is an exceedingly difficult dragonfly to catch. I have taken a single specimen there. In 1949, 35 males were taken August 21, from noon to 5.00 P.M., 14 males August 25, 1 male September 2, 8 males September 26, and 3 females were seen but not collected October 1. In 1951 the species was scarce; 2 males were taken September 3 and 1 male Sept. 24. It was fairly common August 22, 1952, when 5 males were secured, and again on Sept. 9, when 6 males were captured.

21. *Gomphus ventricosus* Walsh. **Williams.** This species is rather common some seasons along Fish Creek and the St. Joseph's River north of Edgerton. The flight season is rather brief; most of my specimens have been taken in June. Three males and 3 females were taken June 14, 1950, at Fish Creek and the St. Joseph's River; a female was taken at the same location June 18, 1952.

22. *Gomphus villosipes* Selys. ***Lucas, *Paulding, *Williams.** A female was taken while ovipositing in a pond in Gale Run, Lucas County, June 23, 1952. Three males were taken June 22 and July 1, 1951, at a muddy pond at the Auglaize Quarries southeast of Junction, Paulding County. One female was secured while ovipositing in algae in a pond in Florence Township, Williams County, June 16, 1950. Six males were secured at a small pond in Northwest Township, Williams County, June 18, 1954. The Paulding County record seems surprising; I had always supposed the species occurred at clear-water ponds.

24. *Dromogomphus spinosus* Selys. ***Paulding.** One male was taken August 7, 1950, on a boulder in the Maumee River one half mile above the Forder Bridge.

25. *Dromogomphus spoliatus* (Hagen). ***Fulton, Paulding, *Williams.** This species is often so wary that it is an exciting insect to capture. Sometimes it will alight on a stone or log lying in the water and slowly turn round and round as if very alert for danger; at other times it may be easily taken. One female and 3 males were captured August 19, 1953, on Flatrock Creek, above the dam at Paulding. The female was taken while she was ovipositing in the water while flying slowly and tapping the tip of the abdomen in the water. The species was very common August 15, 1956 along the Little Auglaize River west of Oakwood, Paulding County. Six males and 1 female were taken July 17, 1956, at Harrison Lake, Fulton County; another male was taken at the lake on August 11. A male was secured August 8, 1956 at a large gravel pit in Madison Township, Williams County.

28. *Basiaeschna janata* (Say). **Williams.** This is a common species at Nettle Lake. Sixteen specimens taken during the eight year period have been males and were taken from May 15 to June 14 (average date, June 5). The species prefers sunny lanes in woods.

30. *Boyeria vinosa* (Say). **Williams.** The nervous flight of this species together with its brown wings and body, make it a difficult insect to take. It is generally common along Fish Creek and its confluence with the St. Joseph's River, but was scarce in 1952 and 1953.

31. *Anax junius* (Drury). **Defiance, Paulding, *Van Wert, Williams.** My collecting in 1951 and 1952, began with specimens of this hardy species. One male was taken at a small pond near Nettle Lake, April 27, 1949; the weather was warm and fine and several were seen, and some were in copula. A small male was taken April 16, 1952, and several were seen. Two males were taken August 3, 1949, at the tiny deep pond at the sawmill at Schumm in Van Wert County. On September 6, 1952, I watched a large number (probably several thousand) flying southward and southeastward; they were watched for several minutes; finally only a few were seen. It is unusual to take males with bluish abdomens during the fall; at that time nearly all have pinkish abdomens. They are very wary then and do not have the appearance of tenerals.

32. *Anax longipes* Hagen. ***Paulding.** Two males of this large and handsome species (of five seen) were taken at a pond of the Paulding Sugar Company July 21, 1949; they were taken at intervals in the afternoon between light showers. They were very wary and were secured with difficulty by means of a special large net with a five-foot handle. They patrolled a beat near several trees where I suspected a female was hidden in the foliage. They sometimes grasped each others abdomens. Two males were seen the following afternoon and one was secured and donated to The Ohio State Museum. Two small boys told me about seeing large red dragonflies at a pond near Charloe, and a farmer remarked about the large red dragonflies that he saw flying over the Maumee River upstream from the Forder bridge, in July, 1949. I saw two of them flying at Mud Lake June 22, 1949; one had a brilliant red abdomen; they flew 10 or 15 feet above the water.

33. *Nasiaeschna pentacantha* (Rambur). ***Paulding, *Williams.** A male was taken June 12, 1950, at an artificial pond along the Miami Canal southwest of Charloe in Paulding County; several were seen but they were too wary for me. On June 3, 1951, two males were taken at a pond near Nettle Lake; several were observed. This species is fairly common at Nettle Lake and ponds nearby. I find them difficult to collect.

34. *Epiaeschna heros* (Fabricius). **Paulding, Williams**. This is the largest of our local dragonflies. On June 6, 1950, 11 females were secured in the Miami Canal southwest of Charloe in Paulding County. Some were ovipositing on trunks of small trees growing in the canal, both below the water line as well as some inches above it. One oviposited six feet above the water in the stem of a wild rose bush. Two tried to oviposit on rusty tin cans. Wet pieces of wood were favorite places. One female was taken at the same locality by hand June 12, 1950; about 25 were seen; they would have been very easy to collect. On June 10, 1950, three females were taken at Dehn's Swamp in Williams County, and two females were taken at a pond beside Nettle Lake. I do not recall ever seeing this species as late as July 1.

141. *Aeshna canadensis* Walker. ***Defiance, Williams**. A new State record. The Defiance County specimens were taken at Lehman's (Big) Lake in 1951; one male was taken Oct. 1, 2 males and 1 female Oct. 2, and 1 female Oct. 5. Lehman's Lake is very shallow and much of it is covered with pickerel weed. The Williams County specimens were secured at a shallow marshy pond on the Ohio- Indiana state line. The pond contains about 8 acres; only about 1 acre lies on the Ohio side, which is the best place to collect. One male was taken September 29 and 1 female Oct. 5, 1951, on the Ohio side. A male was taken at Mud Lake September 14, 1951. This was the only species of Aeshna observed at Mud Lake on September 26, 1956, when 4 males and 1 female were secured from 10 A.M. to 1 P.M. In life this species closely resembles *A. verticalis*. Apparently it is a late-season species.

35. *Aeshna clepsydra* Say. **Williams**. I have taken the species only at Mud Lake, where it is irregular in occurence. Two males were secured August 28, 1950, and 3 or 4 more were seen. Four males were taken September 14, 1951, and 2 males September 21. A male taken September 9, 1955, was the only Aeshna seen. In flight this species appears paler than the other species of Aeshna. Kellicott recorded this species for Ohio but his description of the marks on the side of the thorax definitely does not fit this species.

36. *Aeshna constricta* Say. **Defiance, Paulding, *Putnam, Williams.** This is our commonest *Aeshna*. It was very plentiful at a pond in Florence Township, Williams County, in the fall of 1950; 10 males were taken Sept. 10, 46 males and 4 females Sept. 15, 26 males and 8 females Sept. 18, 43 males and 2 females Sept. 20. At Lehman's Lake in Defiance County, 13 males and 1 female were taken Oct. 1, 1950; a total of 225 males and 23 females were taken in 1950; they became common on Sept. 15 and were still fairly common on Oct. 5. Several males have small extra cells in the anal triangles of the hind wings, so that they actually have four cells instead of three; this occurs seven times on right wings and three times on left wings; there are also incomplete veins in the anal triangles of three specimens. The species was common in 1951, but in 1952 was found sparingly everywhere. A single male was taken in Paulding County October 4, 1952. In 1956 the species was the most plentiful that I have ever observed at the Miller City tile pond in Putnam County. None were seen on August 17, but they were abundant Sept. 24; they were still common Oct. 4; On Oct. 28, a single male was seen and captured.

142. *Aeshna interrupta* Walker. ***Williams.** A new state record. A single male was

captured Sept. 21, 1951, at Mud Lake. The two lines on the side of the thorax are very slender, straight and parallel. I immediately recognized it as a species new to my collection. It appears to be race *lineata*. Walker records it for northern Michigan; this record is far south of the usual range. The wings were undamaged and gave it the appearance of a specimen that might have emerged at Mud Lake.

37. *Aeshna mutata* Hagen. **Williams.** This early-season *Aeshna* occurs regularly at Mud Lake. One learns to identify it at a distance by the handsome blue face and compound eyes. It has a short flight season, and by the last of June is uncommon. At Mud Lake one needs a boat and a large net to get this species. When still somewhat teneral it flies over the fields near the lake, but when fully mature seems to be flying most of the time over the water well out from the shore. Five rather teneral specimens were taken at Dehn's Swamp June 4 and 10, 1950; none were highly colored but all had the appendages peculiar to this species. *A. mutata* seems to fly very little in the afternoons.

38. *Aeshna umbrosa* Walker. **Defiance, *Lucas, Paulding, Williams.** This species was found in Paulding County around ditches through fields where there was no shade; two males and 3 females were taken in such a location August 27 and 28, 1951. It was common at a buttonbush swamp near Ladd's Lake in Defiance County in 1951; only one was captured on Sept. 17 but several were seen flying low under the buttonbushes (*Cephalanthus*), where it was almost impossible to capture them. I find this insect hard to see when it is flying in the shade, the usual habitat.

39. *Aeshna verticalis* Hagen. **Paulding, Williams.** I have taken this species in very limited numbers. I secured a nice male along a ditch in Paulding County Sept. 4, 1951, by dropping my straw hat over it. Eight males were taken in Williams County from August 9 to September 22, 1950.

43. *Cordulegaster obliquus* Say. ***Williams.** A fine female, flying near some tamarack trees, was taken at Mud Lake May 28, 1952. Two more females were secured June 11, 1953, on a bushy hill near Hayes Lake. A male was taken at the same locality June 19, 1956, and another small male 3 days later along a streamlet through brushy woods in Bridgewater Township. The yellow spear-shaped spots on the dorsum of the abdomen readily distinguishes this large species.

44. *Macromia illinoiensis* Walsh. **Paulding, Williams,** These dark *Macromias* are often common in August at ripples in the Maumee River, about a half mile above the Forder bridge. They are difficult to see, as their dark bodies blend with the dark water when they fly low just above the surface. The Williams County specimens have been taken from June to September, flying over Fish Creek and the St. Joseph's River. Even when ovipositing the flight of the females is fast and erratic.

45. *Macromia taeniolata* Rambur. ***Fulton, Paulding, *Williams.** This species appears somewhat later in the season than *M. illinoiensis*. It is easier to see, as it is larger and lighter in color. I find a large net with a long handle almost a necessity to take it. Nearly all of my specimens have been taken in August. It is common on the Auglaize and Little Auglaize Rivers but is rather scarce on the Maumee. Two males were taken at Nettle Lake, August 25, 1949, and another male was taken there August 13, 1953. Four males were secured August 11, 1956, at Harrison Lake in Fulton County.

135. *Macromia wabashensis* Williamson. ***Paulding.** A female with beautiful flavescent wings was taken June 22, 1951, along the Miami Canal near Charloe. Though somewhat teneral she flew well and proved very hard to capture. My only other specimen of this species was taken several years previously along the same canal. Both specimens were taken in June, while my earliest record for *M. taeniolata* is July 16. It is possible that these may merely be rather immature specimens of *M. taeniolata*.

49. *Epicordulia princeps* Hagen. ***Paulding, *Van Wert, *Williams**. This beautiful species is fairly common at Nettle Lake, but I have captured only one specimen there; a male was taken June 18, 1954. A male was taken June 4, 1944, at the abandoned stone quarry at Willshire in Van Wert County. This record was overlooked in my previous paper. A male was taken July 22, 1949, at Klinger's gravel pit in Paulding County. Another male was secured August 15, 1956, at a pond north of Melrose in Paulding County. The species is rare in the latter county.

50. *Tetragoneuria cynosura cynosura* (Say). **Williams.** The species is common in Williams County. I have taken a few specimens in May but many were tenerals. They are more in evidence in early June; by the latter part of the month they have nearly disappeared. I have collected them whenever I can in the hope that *T. morio* or *T. spinigera* will turn up.

134. *Somatochlora ensigera* Martin. **Paulding, *Williams.** This species is much less crepuscular than *S. hineana* or *S. linearis*. It seems to prefer ditches, with or without trees along them. The abdomen of the female (with the anterior segments keeled on the dorsum, while the remaining segments are cylindrical), is so different from the females of the other three Ohio species that one wonders if they do not belong in a separate genus. Four males were taken along a ditch near my home in Paulding County on August 2 and 3, 1951. The extensive dredging of ditches in the past five years has probably destroyed a great many of the nymphs. A Williams County specimen was taken at Mud Lake June 29, 1949, after an exhausting search through tall herbage near the lake.

51. *Somatochlora hineana* Williamson. ***Lucas, *Williams.** A male of this rare species was captured June 18, 1949, on the bog meadow of Mud Lake; two more *Somatochloras* observed there were believed to be this species. On June 23, 1952, 15 males and 1 female were collected in the forenoon at the Oak Openings State Park in Lucas County. All specimens were taken along a branch of the Wabash Railway, which passes through a bog there. One female was taken while she tried to get down to the shallow water in which tall grasses and sedges grew. Another female was seen entering a deep narrow trench along the railroad track; the trench had a growth of vegetation above it that practically hid it from view. No doubt she intended to oviposit in the water, which was not more than 2 or 3 inches deep. Nearly all of the males were taken in flight; a few were taken on herbage. They were very easy to capture. Another trip was made to this locality on June 22, 1953, to try for more specimens. One female was taken about one-fourth mile farther west while she was hawking for insects near a narrow trench. Three males were seen but were far too wild to capture. A male and female were taken at the same location July 1, 1956. A female with an egg bundle was secured June 19, 1956, at a shallow pond in Bridgewater Township, Williams County. I presume that the flight season is very short. Two males were donated to Dr. E. M. Walker, the author of the magnificent monograph on the genus. In his letter of appreciation he wrote "I never expected to see this rare species, much less receive specimens for the Museum. It is a most striking insect, on account of its remarkable appendages. I compared it with the only specimen we have of *S. ozarkensis* and found them nearly related but quite distinct."

133. *Somatochlora linearis* (Hagen). **Paulding, *Williams.** This is our most common *Somatochlora* locally, and occurs regularly in Paulding County. I know of two streamlets through woods where one can find some of them every season in August. They are found less regularly around ditches and borders of woods but are fairly common in such locations some years. On August 12, 1955, 5 males and 1 female were taken at a streamlet in the woods near the mouth of Flatrock Creek. The female was ovipositing in mud at the edge of a shallow pool. Three males were swept down from trunks of small trees or the dead branches of trees leaning over the stream, and two males were taken in flight. The stream was dry except for occasional pools. A female was secured near Dehn's Swamp in Williams County June 28, 1950, while she was hawking for insects. Oddly enough I have noticed very few *Somatochloras* in Williams County.

54. *Perithemis tenera* (Say). ***Fulton, *Henry, Paulding, *Van Wert, Williams.** These are common insects at ponds and lakes and even along some streams, especially above dams.

55. *Celithemis elisa* Hagen. ***Auglaize, Lucas, Williams.** A male of this beautiful and common species was taken at the Fish Hatchery near St. Marys, Auglaize County, August 13, 1951. On several occasions I have noticed individuals flying low across fields, two miles or more from a pond or gravel pit.

56. *Celithemis eponina* Drury. ***Auglaize, Lucas, Williams.** Two males were secured at the same station and date as *C. elisa* mentioned above. This is also a common species at ponds and lakes.

57. *Celithemis monomelaena* Williamson. **Williams.** I take the species only at Mud Lake, where it occurs irregularly. One male was taken July 18 and a female August 20, 1950. Five males were secured June 19, and 7 males and 1 female June 25, 1956. The dark markings on the wings make this a conspicuous insect.

60. *Ladona julia* (Uhler). **Williams.** This species occurs regularly and in numbers at Mud Lake from the latter part of May through the month of June; by July the few remaining specimens are usually battered. I find it at no other station.

62. *Libellula cyanea* Fabricius. **Williams.** This species is plentiful at Mud Lake each year; I have never seen it at Hayes or Nettle Lakes. It can be taken throughout the month of July. The two-colored stigma readily separates this species from our other *Libellulas*.

63. *Libellula incesta* Hagen. **Defiance, *Williams.** One male and a pair in copula were collected at Nettle Lake August 18, 1949, where the species is uncommon. I have never seen it at Mud Lake.

64. *Libellula luctuosa* Burmeister. **Defiance, *Fulton, *Henry, *Mercer, Paulding, Williams, *Wood.** The species is common at ponds, lakes, and gravel pits, but may be found sparingly almost anywhere.

65. *Plathemis lydia* Drury. **Defiance, *Fulton, *Henry, Paulding, *Wood.** The species is exceeded in numbers (among the *Libellulas*) only by *L. pulchella*. To me they seem to be the most agile and wary of the *Libellulas*.

66. *Libellula pulchella* Drury. ***Fulton, Lucas, Paulding.** The Ten-spot is our most common Libellula and is found everywhere.

67. *Libellula quadrimaculata* Linnaeus. ***Lucas, *Williams.** One female was taken at Hayes Lake June 1, 1953; another female was secured June 11, 1953, at a permanent pond one half mile west of Hayes Lake. Two males were taken June 2, 1955, at the Oak Openings in Lucas County. These are my only captures.

68. *Libellula semifasciata* Burmeister. ***Lucas.** One male was taken June 23, 1952, along the railway at the Oak Openings State Park. This species is very irregular in occurrence; some seasons it is common and other seasons it is rare. It is observed more often in May and early June when it does occur. I have seen none since 1952.

69. *Libellula vibrans* Fabricius. **Paulding.** Three males of this large handsome *Libellula* were taken along the Miami Canal June 25, 1950. They flew in the shade of small trees growing in the canal and were hard to capture. A fine male was taken at the same locality southeast of Charloe June 26, 1951.

70. *Sympetrum ambiguum* Rambur. **Mercer, Paulding.** One male of this green-faced *Sympetrum* was secured August 27, 1952, at the Grand Reservoir. Three males were taken along the Miami Canal near Charloe August 25, 1950. This is a rare species as a rule but I considered it the most plentiful of the *Sympetrums* in August 1944.

71. *Tanetrum corruptum* (Hagen). **Paulding.** One female was taken while hawking for insects along a ditch and road in Benton Township August 10, 1949; I have seen none since. They were common during two seasons in the past 12 years. Due to their large size it is easy to confuse them in flight with both *Pantala hymenaea* and *P. flavescens*. They are more wary than the *Sympetrums*.

144. *Sympetrum costiferum* (Hagen). ***Lucas, *Paulding, *Putnam, *Williams.** A new state record. On October 4, 1952, a pair was seen in tandem while the female oviposited by tapping the tip of the abdomen in a shallow pool of Flatrock Creek southwest of Payne. The female had flavescent streaks along the costal margins of the wings and also had the vulvar lamina peculiar to the species. On October 19 and 21, 1953, 37 males and 6 females were taken at permanent ponds in the vicinity of Hayes Lake in Williams County. On November 2, 1953, a single male was taken at a pond west of Hayes Lake, where the only other Odonata seen were several specimens of *S. vicinum*. Most of them had battered wings. I estimated that they emerged about October 1. Two males were taken at a pond on Gale Run at the Oak Openings October 23, 1953. At the Miller City tile pond in Putnam County, 2 males were secured Sept. 4, and 3 males October 4, 1956. I found that I could generally distinguish the species while resting or in flight. Late collecting may turn up many more records for Ohio.

143. *Sympetrum internum* Montgomery. ***Paulding, *Putnam, *Williams.** A new state record. A male was collected at a nearly dry boggy pond in Northwest Township, Williams County Sept. 24, 1951; on Sept. 26, 10 males and 1 female were taken at the same place. A thorough search on Oct. 14, 1951, failed to turn up a single specimen. Another search was made at the pond in 1952 but none were seen. A single male was collected at a pond 2½ miles east of

Hayes Lake Oct. 21, 1953. At a pond near the mouth of Blue Creek in Paulding County 5 males were taken Oct. 4, 1954. Five males were taken at the Miller City tile pond in Putnam County Sept. 24, 1956 and another male Oct. 4. In favorable artificial light a golden shadow will show on white paper held under the wings. This appears to be a late season species and should be searched for in September. Synonyms for the species are *decisum* (Hagen). and *rubicundulum decisum* (Hagen).

72. *Sympetrum obtrusum* (Hagen). **Lucas, Mercer, Paulding, *Putnam, Williams, *Wood.** This is a rather common species. My experience has been that the males will generally have a white face in life and can be determined before taking them.

73. *Sympetrum rubicundulum* (Say). **Defiance, *Fulton, Lucas, Mercer, Paulding, Williams.** This is the most common species of Sympetrum here, but I have not found it occuring as late in the season as *S. costiferum* and *S. vicinum*. It appears on the wing about the last of June and may be exceedingly abundant some years. It is found almost everywhere,—at rivers, ponds, lakes, and even fields.

74. *Sympetrum semicinctum* (Say). **Lucas, Paulding, *Putnam, *Williams.** Two somewhat teneral males were taken at Mud Lake July 9, 1951. Two males were secured August 17, 1956, at the Miller City tile pond in Putnam County. The species was locally common in Paulding County in 1956; five males were taken along a ditch on July 13. It is not a common species here and it has a short flight season.

76. *Sympetrum vicinum* (Hagen). ***Lucas, Paulding, Williams.** Two males and 3 females were taken at the Oak Openings Sept. 3, 1952. This small and common red-faced species is usually the last Odonata I collect in the fall; it often occurs in large numbers.

77. *Leucorrhinia intacta* Hagen. **Lucas, Williams.** This is an abundant species at ponds, lakes and canals in this area. A specimen taken in Williams County was determined by Dr. Borror as an odd specimen of this species; it lacks yellow spots on the dorsum of the seventh abdominal segment.

78. *Pachydiplax longipennis* (Burmeister). **Defiance, *Henry, Lucas, *Van Wert.** This is another common species found almost everywhere during the summer. A male was taken at the Schumm sawmill in Van Wert County August 3, 1949.

79. *Erythemis simplicicollis* (Say). ***Auglaize, *Fulton, *Henry, Lucas, *Mercer, Paulding.** The species is common at lakes and ponds. It seems to prefer Diptera and small Odonata for food. Two males were taken at the St. Marys Fish Hatchery August 13, 1951, and 1 male was secured at a pond on the west side of the Grand Reservoir in Mercer County August 27, 1952.

80. *Pantala flavescens* (Fabricius). ***Defiance, Paulding, *Van Wert, *Williams.** One male was taken at the old stone quarry at Willshire August 3, 1949. A male was secured June 24, 1950, at a marl pit near Nettle Lake. A male was captured July 8, 1956. along the Miami Extension Canal in Defiance County. This species is rather uncommon in the area; it is very agile and wary, and I have taken very few specimens.

81. *Pantala hymenaea* (Say). ***Defiance, *Lucas, *Mercer, *Van Wert, *Williams.** One male was taken August 27, 1952, at a pond west of the Grand Reservoir. The Williams County specimen was secured June 24, 1950, at a marl pit near Nettle Lake. Two males were collected at the stone quarry at Willshire August 30, 1949, for the Van Wert County record. A female was captured July 1, 1956, at sand pits at the Oak Openings in Lucas County; it was quite common then. A female was taken July 8, 1956, along the Miami Extension Canal in Defiance County. I find the species much easier to capture than *P. flavescens*.

82. *Tramea carolina* (Linnaeus). ***Williams.** One male was taken at a small pond near Nettle Lake June 3, 1951. While it was flying the wing spots appeared to be bright red, but before I placed it in the cyanide bottle the color had changed to brown. This is a rare species in this area, and I find it extremely difficult to catch.

83. *Tramea lacerata* (Hagen). ***Henry, *Mercer, Paulding, *Van Wert.** A pair were taken August 27, 1952, at a pond west of the Grand Reservoir in Mercer County. Two males were taken August 30, 1949, at the old stone quarry at Willshire in Van Wert County. A teneral female was found August 17, 1956, floating in water (but still living) in a pond near Napoleon in Henry County. The species is common.

85. *Calopteryx aequabile* Say. **Williams.** A male and female were collected June 14, 1951,

at a streamlet southwest of Edgerton. I have found this species only around small spring-fed streams. Due to its brief flight season it may be much more plentiful than is generally believed.

87. *Calopteryx maculatum* (Beauvois). **Lucas, Paulding, Williams.** The Black-winged Damsel Fly seems to prefer well shaded streams with ripples, but is found sparingly even in ditches and lakes. It is common and easily taken from June to early September.

88. *Hetaerina americana* (Fabricius). ***Lucas, Mercer, Paulding, Williams, *Wood.** The Lucas County specimen was taken below the Providence Dam in the Maumee River August 1, 1952. The Ruby-spot is a common species, found along many streams especially where Water-willow grows. This species was common along Flatrock Creek southwest of Payne in 1943, but has not been observed there since.

89. *Hetaerina titia* Drury. ***Paulding, *Williams.** This rare and beautiful species occurs regularly each season along Fish Creek and the St. Joseph's River north of Edgerton. It is a late season species, much more wary than *americana*, and generally alights higher up on bushes and trees along the bank of the stream, where it is out of reach of the collector. It flies from the last week of August to the first week of October. On August 25, 1953, a male was taken after he released the female. Five males were taken September 2 and 5, 1955, along the Maumee River above the Forder bridge.

91. *Lestes congener* Hagen. ***Lucas, Paulding, *Putnam, Williams.** This small *Lestes* is a late-season species; I take it later than any other *Lestes*. I consider it rather common, as I have observed it in large numbers at some of the Williams County ponds. One male was taken at the Oak Openings Park in Lucas County October 23, 1953. None were seen at the Miller City tile pond in Putnam County September 24, 1956, but 2 males and 1 female were secured October 4, and they did not become common until Oct. 28.

92. *Lestes disjunctus australis* Walker. **Defiance, Lucas, Paulding, *Williams.** A pair was taken in copula June 6, 1949, at a pond near Nettle Lake. I sometimes take this common species as early as the latter part of April. Dr. Borror has examined a number of my specimens labelled *L. forcipatus* and has determined them to be this species. I consider all of my records of *L. forcipatus* questionable.

93. *Lestes eurinus* Say. ***Lucas, *Paulding, *Williams.** A male was secured at a pond of the Paulding Sugar Company at Paulding July 21, 1949 and the following day a battered female was taken at the same place. A male was taken at a pond near Charloe July 14, 1950. On June 28, 1951, 9 males and 2 females were collected at a pond in Florence Township, Williams County. Nine males were taken July 1, 1956, at a sand pit at the Oak Openings Lucas County. This large species is not common at ponds in Paulding County and is uncommon to fairly common at certain Williams County ponds. It probably is more common in Ohio than is generally believed.

95. *Lestes inaequalis* Walsh. **Williams.** This insect occurs sparingly at Mud Lake, where 3 males and 1 female were taken July 9, 1951. On June 17, 1953, 6 males were taken at a pond 2½ miles east of Hayes Lake. This species is not as robust as *eurinus* but seems to be a heavier insect than *vigilax*. It is rare and local.

96. *Lestes rectangularis* Say. **Defiance, Lucas, Paulding, *Putnam, Williams, *Wood.** This is a common species along ditches, ponds and swamps,—in fact, almost everywhere. Several specimens were taken at Dehn's Swamp in Florence Township, Williams County; Dr. Borror termed the males the smallest he had ever seen of the species. I have never been able to take males of this species so late in the season elsewhere.

97. *Lestes dryas* Kirby. **Defiance, Fulton, Paulding, Williams.** This is a common or even abundant species in June at temporary ponds or swampy areas. It usually occurs in large numbers wherever found.

98. *Lestes unguiculatus* Hagen. **Lucas, Paulding, *Putnam, Williams, *Wood.** This is a common species along ditches, streams, ponds, etc.

99. *Lestes vigilax* Hagen. **Williams.** A rare and delicate species that is more delicate than *inaequalis* and is easily distinguished from that species by the inferior appendages of the males. I have found this insect only amongst herbage at Mud Lake. Seven males have been taken on the following dates: June 22, 1949, July 1 and 18, 1950, and July 9, 1951.

100. *Argia apicalis* (Say). **Lucas, Mercer, Paulding, *Van Wert, *Wood.** This is a very common insect. Two males and 1 female were taken August 31, 1949, at a small deep pond at Schumm's sawmill in Van Wert County.

102. *Argia moesta* (Hagen). ***Lucas, Paulding, *Williams.** This is a common species on the Maumee and Auglaize Rivers but is scarce on the St. Joseph's River. A single male was taken on a boulder in the St. Joseph's River in Williams County June 21, 1949. The Lucas County male was taken below the Providence Dam on the Maumee River Aug. 1, 1952. A male taken at the Maumee River in 1948 was badly used up but still very much alive and able to fly; one wing was broken off near the nodus, two wings were broken off halfway between the nodus and stigma, and only segments 1, 2, 3, and part of 4 of the abdomen remained. The end of the abdomen was dry, indicating that the damage had been done some time previously.

103. *Argia sedula* (Hagen). **Williams.** Four males were taken at a gravel pit in Northwest Township August 7, 1952. This is the least common of the Argias that I have collected.

104. *Argia tibialis* (Rambur). ***Henry, Williams.** This is a rather common species especially around herbage along rivers and creeks.

105. *Argia violacea* (Hagen). ***Henry, Williams, *Wood.** This is probably the commonest species of *Argia* in this area; it probably occurs around every pond, stream and lake.

106. *Amphiagrion saucium* (Burmeister). **Williams.** Seven males of this small red species were collected June 17, 1953, at a spring-fed streamlet southwest of Edgerton. Two females were taken May 21, 1955, at a streamlet that formed the outlet for Hayes Lake; several more were observed. The species has a short flight season in late May and June. It probably is common in Williams County.

107. *Nehalennia gracilis* Morse. ***Williams.** A single male of this delicate species was taken at Mud Lake July 9, 1951, during a shower. This is my only Ohio specimen. *N. irene* was common at the same place. At Cedar Lake in Lagrange County Indiana, this species is plentiful during the first half of July; it flies with *Nannothemis bella* at a bog there. I found that the best way to take *gracilis* was to drop a large net over the sedges and the insect would rise to the top where it could be easily seen.

108. *Nehalennia irene* Hagen. ***Fulton, Paulding, Williams.** Three males were taken at a slough of Flatrock Creek southwest of Payne July 18, 1951, and several others were seen. This is a rather common species locally and is not strictly a bog species like *gracilis*.

109. *Chromagrion conditum* (Hagen). **Williams.** This species was common in 1951 at a little sedge-choked stream near Columbia. On June 3 and 7 I collected 20 males and 6 females and saw many more. Several pairs were observed in copula; sometimes both would cling to a sedge blade in tandem while the female oviposited in tissues of the dead or living plants. Some males would hold themselves erect in a vertical position such as one often sees in *Argia moesta*. By June 17 this species had disappeared.

110. *Enallagma antennatum* (Say). **Mercer, Paulding, Williams.** This is a common species at ponds, lakes, and gravel pits.

111. *Enallagma aspersum* (Hagen). ***Fulton, *Lucas, *Paulding, Williams.** One male was taken June 23, 1952, at the Oak Openings Park in Lucas County. Four males were secured at the ponds of the Paulding Sugar Co. at Paulding Aug. 2, 1949 and June 25, 1950. This is much more common than I had believed.

129. *Enallagma basidens* Calvert. ***Fulton, Paulding, Van Wert, Williams.** A pair in copula was taken at the old stone quarry at Willshire, Van Wert County, Aug. 30, 1949. Two males were taken at Harrison Lake, Fulton County, July 17, 1956. This species probably occurs at every gravel pit and stone quarry in this area.

112. *Enallagma boreale* Selys. **Defiance, Williams.** Both *boreale* and *cyathigerum* are rather large *Enallagmas*. I have found both species at the same ponds. The height of their flight season is about the first half of June.

113. *Enallagma carunculatum* Morse. ***Fulton.** My only Ohio specimen is a male taken July 17, 1956, at Harrison Lake. I have made considerable effort to take the species at Grand Reservoir. Apparently the species has declined in numbers since Kellicott's time as he wrote (1899), "It has been noted in myriads about Mercer County Reservoir and at Sandusky Bay in July."

114. *Enallagma civile* (Hagen). **Auglaize, *Fulton, Mercer, Paulding, *Van Wert, Williams, *Wood.** I consider this to be our most common species of Enallagma at ponds and lakes.

140. *Enallagma cyathigerum* (Charpentier). ***Lucas, *Williams.** A new state record. Two males were taken at a pond on the east side of Nettle Lake, June 5, 1949. From June 6 to

19, 1949, 31 males were taken at this pond. The species has been consistently taken at ponds in Williams County since then. A male was taken June 23, 1952, at a sand pit at the Oak Openings Park, for the Lucas County record.

115. *Enallagma divagans* Selys. ***Williams.** At a deep hole from which water flowed constantly, along a streamlet southwest of Edgerton, 6 males and 1 female were taken June 14, 1951, and 5 males were taken on June 17. At that time they were scarce. On June 17, 1953, a pair in copula was taken at the same place. This is a rare and local species.

117. *Enallagma ebrium* (Hagen). **Lucas, *Paulding, Williams.** This species is abundant in Williams County and rare in Paulding County. A male was taken at an artificial pond 2 miles north of Melrose July 23, 1951, for a Paulding County record.

118. *Enallagma exsulans* (Hagen). **Mercer, Paulding, Van Wert, Williams, *Wood.** This species is even more generally distributed than *civile*, being taken at creeks and rivers as well as at lakes.

119. *Enallagma geminatum* Kellicott. ***Auglaize, Defiance, *Lucas, Williams.** Three males were taken at the St. Mary's Fish Hatchery in Auglaize County Aug. 13, 1951. The record for Lucas County was a male taken June 23, 1952, at a pond on Gale Run. I have taken this species only at clear water lakes and ponds.

120. *Enallagma hageni* Walsh. **Defiance, *Fulton, Williams.** This is a rather common early-season species in the 3 counties.

121. *Enallagma signatum* (Hagen). ***Auglaize, Defiance, Paulding, Williams.** One male was collected at the St. Mary's Fish Hatchery Aug. 13, 1951, for an Auglaize County record. This is a rather common species.

122. *Enallagma traviatum* (Selys). **Williams.** I consider this a rare species. One male was taken at Mud Lake June 29, 1949, and another male was secured June 12, 1949, at Nettle Lake. I don't recall ever taking this insect at a small pond.

123. *Enallagma vesperum* Calvert. **Williams.** One male was taken at Nettle Lake Sept. 6, 1949, and 1 male was taken at Mud Lake June 11, 1950. This species was abundant one season at Little (Krill's) Lake in Defiance County but has not been seen during the time covered by this paper.

124. *Ischnura posita* (Hagen). **Defiance, *Fulton, Lucas, *Mercer, Paulding, *Wood.** This is a common species, but not as abundant as verticalis. The Mercer County specimen was taken at Achbach's Landing at Grand Reservoir, August 13, 1951.

126. *Ischnura verticalis* (Say). **Defiance, *Henry, Paulding, Williams, *Wood.** This is such a common insect that I collect very few specimens.

127. *Anomalagrion hastatum* (Say). **Paulding, *Williams.** Four males were taken at a shallow pond near Nettle Lake July 17, 1949. One male was secured at the tile pond at Haviland in Paulding County, July 30, 1949. The tiny species is local.

THE PREY OF ODONATA

The writer has frequently taken Odonata with prey; a summary of these collections, where the prey was identifiable, is given in table 1. Of the 29 records here reported, the prey in 11 cases was other Odonata (8 of Zygoptera and 3 of Anisoptera); in each case an anisopteran was the predator. In 10 cases the prey was Diptera, in 6 it was a butterfly, and there was one instance each of a mayfly and a caddisfly as the prey.

ODONATA TAKEN AS PREY

On Sept. 10, 1950, at a pond in Williams County, I took a male *Aeshna constricta* from a spider web; it had both left wings fastened in the web. Another male of the same species taken at the same place ten days later also had both left wings fastened in a spider web; it was still alive and struggling. A male *Somatochlora linearis* taken Aug. 20, 1947, at a streamlet in Paulding County, was in a web over the stream and under some trees. A large spider (probably an *Argiope*) was eating it at the time. Arthur Brooks once called my attention to a leopard frog (*Rana pipiens*) that was jumping at ovipositing females of *Sympetrum*

vicinum at Mud Lake. We watched it for some time and saw it jump several times but never saw it succeed in making a capture.

At the Oak Openings in July, 1953, I watched Purple Martins capturing Odonata with the greatest ease. They would swoop low over the water of a small pond and in a few seconds would leave with their prey, apparently for their nestlings. The Odonata taken were mainly *Libellula spp.*, *Anax junius*, *Erythemis simplicicollis* and *Pachydiplax longipennis*.

TABLE 1

Odonata taken with prey

Species	Sex	Date	Locality	Prey
Gomphus exilis	♂	6/24/50	Nettle Lake	Damselfly, *Enallagma antennatum*
Gomphus externus	♂	8/3/47	Maumee River	Butterfly, *Pieris rapae*
	♂	6/14/46	Fish Creek	Fly (Diptera)
	♂	6/22/47	Flatrock Creek	Fly (Diptera)
Gomphus fraternus	♂	7/6/47	Fish Creek	Fly (Diptera)
	♀	6/8/48	Fish Creek	Crane fly
	♂	6/8/48	Fish Creek	Crane fly
	♂	6/4/50	Fish Creek	Crane fly
	♀	6/11/53	Pond, Williams Co.	Butterfly, *Phyciodes tharos*
Gomphus graslinellus	♀	6/12/52	Nettle Lake	Crane fly
	♀	6/2/48	Maumee River	Teneral gomphine dragonfly
Gomphus vastus	♂	6/2/48	Maumee River	Teneral dragonfly, *Gomphus fraternus*
	♀	8/5/48	Maumee River	Damselfly, ♂ *Argia moesta*
Gomphus ventricosus	♂	6/8/46	Fish Creek	Crane fly
	♂	8/5/46	Eagle Creek	Butterfly, *Pieris rapae*
Dromogomphus spoliatus	♂	8/25/50	Brown Twp., Paulding Co.	Butterfly, *Pieris philodice*
	♂	8/19/49	Flatrock Creek	Butterfly, *Phyciodes tharos*
Basiaeschna janata	♂	6/5/49	Mud Lake	Dragonfly, *Leucorrhinia intacta*
Boyeria vinosa	♂	9/8/46	Fish Creek	Damselfly, *Hetaerina titia*
Anax junius	♂	4/29/48	Mud Lake	Mayfly
Libellula pulchella	♂	6/23/44	Miami Extension Canal	Damselfly, *Lestes* sp.
Leucorrhinia intacta	♂	6/16/46	Pond, Williams Co.	Damselfly, *Ischnura verticalis*, ♀
	♂	6/17/44	Miami Extension Canal	Deer fly, *Chrysops* sp.
	♀	8/28/45	Nettle Lake	Fly (Diptera)
	♀	7/20/49	Pond, Paulding Co.	Damselfly, *Enallagma civile*
Erythemis simplicicollis	♀	7/22/49	Pond, Paulding Co.	Butterfly, *Phyciodes tharos*
	♀	8/2/49	Pond, Paulding Co.	Damselfly, *Enallagma civile*, ♂
	♀	6/28/53	Hayes Lake	Damselfly, *Argia* sp.
Argia moesta	♀	8/5/48	Maumee River	Caddisfly

A pair of Purple Martins had large but unfeathered young in a bird box in our yard in June, 1951. On June 22 and 26, I watched the birds return to the box with Odonata. With the aid of field glasses, I determined one specimen as *Pachydiplax longipennis* and two others as *Anax junius*. Twice after seeing the birds leave after they had carried in an *Anax junius*, I found no trace of the dragonfly nor could I find any trace of its wings on the ground below the nesting box; if the birds carried the wings away in their beaks I failed to see them. It is my opinion that the swallows catch more Odonata than the flycatchers do in this area. If swallows are plentiful at a lake or pond, I have often found the *Enallagma* collecting to be poor at the place.

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To facilitate processing, reviewing, and the subsequent publication of accepted papers, authors henceforth are requested to submit to the Editor two copies of their manuscripts. The original typed copy and the *first* carbon copy should be submitted, together with complete tables and figures for each copy. In addition to the original illustrations, a photographic copy of each should be included for transmissal to the reviewer. Careful attention should be paid to the instructions for the preparation of manuscripts (cover page 3), and recent issues of the Journal should be consulted. The Journal's style and format must be adhered to, particularly with respect to illustrations and references. Your cooperation and attention to these points will enable the editorial staff to function more effectively, to handle and publish more papers in shorter periods of time, and to serve you better.

The Leibniz-Clarke Correspondence (with extracts from Newton's *Principia* and *Opticks*). *H. G. Alexander*, Editor. Philosophical Library, Inc., New York, 1956. lvi + 200 pp. $4.75.

Brought together in this volume are all of the essentials of the famous philosophical controversy between Leibniz and Clarke, the latter acting chiefly in defense of Newton's *Principia* and *Opticks*.

First published in 1717, the present edition is the first full reprint in English since 1738. A new edition is justified on the premise that post-Newtonian physics has been partially anticipated by the subtleties of some of Leibniz's arguments.

Irrespective of any anticipation of the theory of relativity that may be contained in the correspondence, the entire discussion is now readily available to all students of the history of philosophy.

DUNCAN MCCONNELL

Building an Engineering Career. *Clement C. Williams* and *Erich A. Farber*. Third Edition. McGraw-Hill Book Co., New York, 1957. x + 299 pp. $4.75.

The preface of this third, largely rewritten edition lists nine specific objectives, which are headed by: (1) "To give a preview of the character of the engineering profession and its relation to social organization. . .," and (2) "To assist the student in adopting efficient study methods. . . ." These and the remaining seven comprise extremely difficult, self-imposed assignments.

Professor Farber mentions "the launching of the first man-made earth satellite is planned for 1957," without mentioning by whom—a matter that might have been difficult to predict without an appraisal of America's evaluation of science and engineering in terms of gadgeteering ability.

The dependence of engineering on research in the basic sciences is inadequately considered.

This book should be compulsory reading for every vocational counselor connected with a high school.

DUNCAN MCCONNELL

Philosophy of Science, The Link Between Science and Philosophy. *Philipp Frank*. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1957. xxii + 394 pp. $7.65. Test—$6.00.

In this book Professor Frank explores some of the interrelations between philosophy and science in an attempt to reconcile any separation in viewpoints that may have arisen between scientists and humanists.

Although major portions of the book appear to have been written for the educated lay reader, other portions will interest mature scientists—particularly the chapters on "Theories of Higher Generality" and "Metaphysical Interpretations in Physics."

Throughout the discussions of the relevance and interdependence of physics and philosophy—especially discussions of Einstein's theory of relativity—this reviewer continually sensed an implied restraint of philosophy by the bounds of mathematical development. That Enistein's theory may be quite as incomplete in 2200 A.D. as is Newton's theory today does not seem to have been given adequate credibility, and there appears to be no cogent reason why abstract thought cannot develop independently of the mathematics.

By "science" the author means physics, to the virtual exclusion of life sciences. Promulgation of this popular misconception is unfortunate.

DUNCAN MCCONNELL

The Path of Carbon in Photosynthesis. *J. A. Bassham* and *M. Calvin*. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1957. x + 104 pp. $3.00.

This book will be of particular interest to the botanist and the biochemist who feel the need for a summation of the biochemical studies that are currently leading to a more fundamental understanding of the intricate processes concerned in photosynthesis. A brief historical background culminates in a discussion of the new methods involving tracer elements and paper chromatography. This, along with analytical procedures and a brief discussion of desirable plant material, introduces the reader to the basic objective of the development and presentation of the Photosynthetic Carbon—Reduction Cycle through the use of radiocarbon. The involved chemical reactions, with their appertaining energy and enzyme systems are illustrated by figures and tables. The use of radiocarbon is extended to a brief discussion of fat and amino acid synthesis. Metabolic inhibitors, hydrogen transfer, oxygen evolution and quantum conversion are dealt with briefly because of their involvement in photosynthesis. The material is documented by 142 references which contribute to the versatility of this concisely written monographic reference work.

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